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OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

W. F. KING
Chief Astronomer
Ottawa

R. F. STUPART
Director of the Meteorological Service of Canada, Toronto

J. S. PLASKETT
Dominion Observatory
Ottawa

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Editorial communications should be addressed to C. A. Chant, University of Toronto, Toronto, Ont.

Business correspondence, remittances, etc., should be addressed to Chas. P. Sparling, Treasurer of the Society, 530 Dovercourt Rd., Toronto.

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PLATE XIX.

EDMUND HALLEY (b. 1656 — d. 1742).
ASTRONOMER ROYAL 1720-1742.

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THE SPECTROSCOPIC BINARY, α CORONÆ BOREALIS

BY J. B. CANNON

THE star α Coronæ Borealis, ($\alpha = 15^h\ 30^m$, $\delta = +27°\ 3'$) was discovered to be a binary by Hartmann from measures of six plates taken at Potsdam in 1902 and 1903.* It was under observation at this Observatory during the years 1907 and 1908. In all, one hundred and three plates were secured, forty-six in 1907 and the remaining fifty-seven in 1908; the instrument used being the single prism spectroscope.

This star belongs to the class I *a* 2 in the Vogel classification. The spectrum shows the absorption line H_β, H_γ, H_δ, H_ε, maguesium λ 4481, iron λ4549, calcium λ3934 and a few other very faint lines. The hydrogen lines are all very broad and diffuse and very difficult of accurate measurement. H_ε is especially diffuse and it was found impossible to measure it on the plates obtained. λ 4481 varies in character, in some plates well defined, in others diffuse. λ4549 is very faint and was only measured in a very few cases. λ 3934 is in general a fairly good line, being weighted about the same as H_γ and H_δ. In the measurement of nearly every plate it was found that λ4481 and λ4549 gave different velocieties from the H and K lines. It was decided, therefore, to consider only H_β, H_γ, H_δ and K in the first measurements and the elements of the orbit determined in the first part of this paper are from the consideration of these alone.

*A.N. 163, 31, 1903.

The lines of each plate were weighted according to quality. The plate was then weighted as a whole, the general appearance of the spectrum and the agreement of the measures of the various lines being considered. The velocities when plotted gave a period of about 17·35 days. There were available, measures of three plates of 1901 and ten of 1903 taken at Potsdam,* and it was found when plotting these with our own observations that a period of 17·355 days would cause all these early observations with one exception to lie very close to a curve through the observations obtained here.

The one hundred and three observations were then combined into fourteen groups. Plates of both years were combined indiscriminately, those at nearly the same phase being grouped together. The weight of each plate was taken into account and the weighted mean of each group computed, together with the mean phase calculated from the time of periaston finally accepted.

(Table 1 contains the mean phase, mean velocity, weight and residuals of these fourteen normal places, the residual being the difference between the normal and the value computed from final elements).

TABLE I.

NORMAL PLACES

No.	Mean Phase	Mean Velocity	Weight	Residuals
1	12·656	− 29·77	6	+ 2·37
2	13·777	− 23·54	2	− 2·34
3	14·664	− 18·50	3	− 2·29
4	15·831	− 5·77	2·5	− 0·36
5	16·723	+ 5·00	1·5	+ 6·22
6	0·556	+ 34·60	4	− 2·17
7	2·302	+ 37·14	6	− 0·17
8	3·559	+ 24·33	3	+ 2·66
9	5·657	+ 11·10	4	− 2·47
10	6·250	+ 2·41	4	+ 1·46
11	7·968	− 6.71	4	− 1·65
12	9·444	− 17·27	2	+ 0·31
13	10·517	− 22·21	3	+ 0·25
14	11·000	− 24·35	3	+ 0·75

From the radial-velocity curve drawn through the normal places the elements of the orbit were determined by the graphic

*A.N. 163, 31, 1903.

method of Dr. King.* The value of pvv computed with these elements was 498·94 and it was thought that this might be reduced by applying least squares. The period was considered as fixed at 17·355 days, the interval between the Potsdam and Ottawa observations being great enough to make this value very nearly accurate. Fourteen observation equations were formed by the Lehmann-Filhés method† and the resulting normal equations solved. The corrections obtained gave new values for the elements which reduced pvv to 217·35, but the differences between ephemeris and observation equation residuals were too large and a second least squares solution was made. This time K' was left out, the correction obtained from the first solution being sufficiently small to justify the omission. This second solution again reduced pvv and gave satisfactory agreement between ephemeris and equation residuals.

The following table gives the values of the elements 1st graphic, 2nd and 3rd after 1st and 2nd least squares solutions.

TABLE II.

ELEMENTS OF ORBIT

Elements	Graphical	After First Solution	After Second Solution
P	17·355 days	17·355 days	17·355 days
T	J.D. 2,417,725·55	2,417,725·101	2,417,725·054
K'	33 km.	32·969 km.	32·969 km.
e	·28	·265	·277
ω'	309°	305°·24	303°·68
γ	0 km.	+ ·635 km.	+ ·498 km.
pvv	498·94	217·35	207·7
$a \sin i$			7,560,000

The probable error of a normal place was computed and found to be ± 3·07 that of a plate as determined from the residual for each plate from the curve to be ± 5·38. The probable error of each element was also computed and is given below,—

of γ	± ·330 km.
e	± ·0012
ω'	± 4°·25
T	± ·187

Astrophysical Journal, Vol. XXVII.

†A.N. 136, 17, 1894.

Since the completion of the foregoing treatment of the binary, from the point of view of the hydrogen lines and the calcium line, λ 3934, all the plates have been reviewed, and the magnesium line λ 4481 carefully measured when measurement was possible, with the intention of determining in what respect the orbit deduced from this line might differ from that already determined from the other lines. The method of treatment was exactly similar to that formerly followed. The period was taken as before — 17·355 days. The observations were grouped into normals, the same plates being taken together as in the former treatment and the relative weights assigned as before. The normals were plotted, and the best curve possible drawn through them, or rather the graphic method of Dr. King was employed to obtain the elements of the orbit, the velocity curve corresponding to which best suited these normal places.

The elements thus found were as follows :—

$$\begin{aligned} \gamma &= +\ 6{\cdot}69 \text{ km.} \\ K &= \quad 33 \text{ km.} \\ e &= \quad {\cdot}35 \\ P &= \quad 17{\cdot}355 \text{ days} \\ \omega &= \quad 316°. \end{aligned}$$

Comparing these with the corresponding elements from the other lines, the main differences are seen to be in the values of γ and e.

In the work which has been done on the radial velocities of stars other than binary, some stars have been found, certain of whose lines gave consistently different velocities from other lines. Among these is *o* Ceti, the emission and absorption lines giving a considerable difference in the value of the radial velocity. So with nearly all Novæ. Nova Aurigæ has been discussed at some length by several astronomers and a similar phenomenon has been noted. Explanations have been suggested as to the cause of the different displacements of different lines. These consist chiefly of two,—first, a lagging envelope producing the lines of less displacement towards the red end of the spectrum, and second, an ever expanding envelope coming from a continuously productive source. How far such conditions would go to explain

a state of affairs such as we find in α Coronæ, it is difficult to say. We may also look upon the system as receding with a velocity of 6·69 km. per second,—the velocity given by the magnesium line,—and constantly expelling hydrogen and calcium vapors. And we may further consider the velocity of expulsion to be affected by the periodic recurrence of physical conditions, brought about by the changing relative positions of the stars in the orbit, and these conditions to be such as to fail to influence

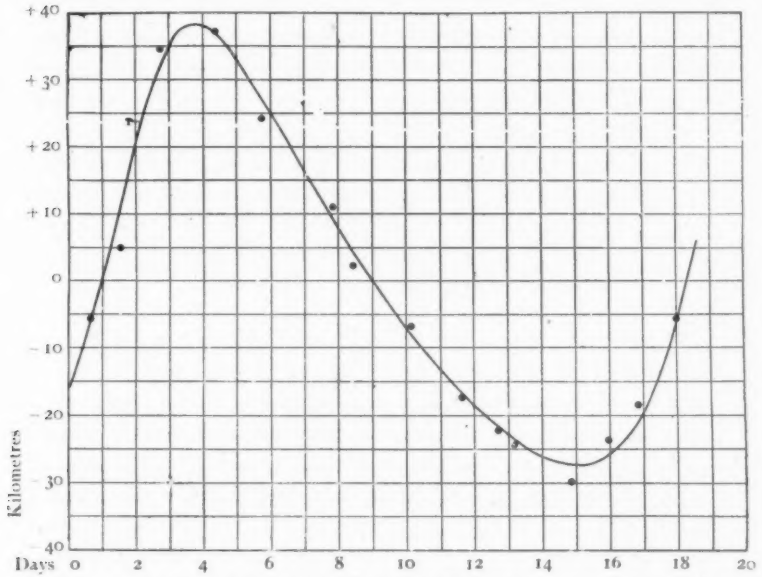


FIG. 1.—VELOCITY CURVE OF α CORONÆ BOREALIS FROM HYDROGEN LINES AND CALCIUM λ 3934

magnesium in any way so far as changes in the lines are concerned. This is quite plausible, for in the spectroscopic study of the Sun's surface, regions have been found, such as sun-spots, the spectra of which show certain lines considerably affected in character and position, while other lines denoting other elements remain unchanged.

After the first part of this work had been completed, Mr. Jordan issued from the Allegheny Observatory his publication on

the orbit of α Coronæ Borealis. Comparing his results with those obtained here from the lines H_β, H_γ, H_δ and K, it was seen that although on the whole they agreed fairly well, there was considerable difference in the values of e. This is largely due, no doubt, to the fact that Mr. Jordan used the line (Mg.) λ 4481 together with the above lines in the determination of his elements. However, the fact that the plates we obtained here were measured by several men and all agreed that the Mg line gave large discrepancies seems to justify the separate treatment.

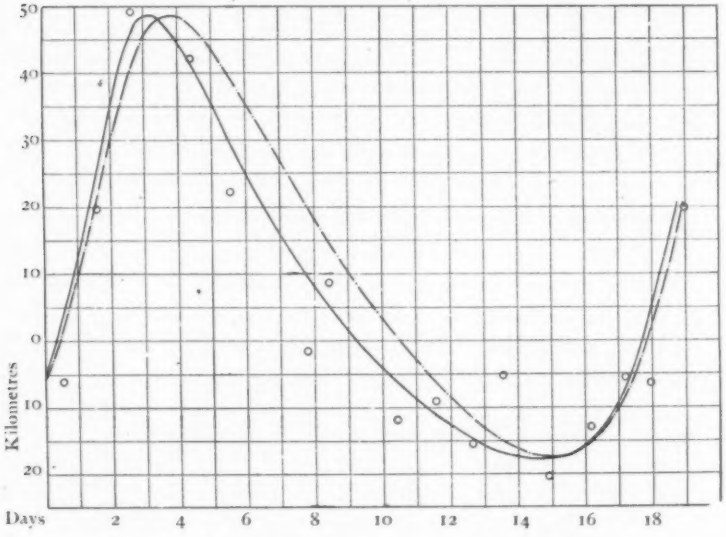


FIG. 2.—VELOCITY CURVE OF α CORONÆ BOREALIS
——Magnesium Curve. -·-· Hydrogen Curve (raised 10 km.)

In conclusion I wish to acknowledge my obligation to Dr. King for the encouragement and help he has given me in this work.

The accompanying curves represent:—Fig. 1, the Hyrodgen and Calcium curve; and Fig. 2, the curve from the Hydrogen and Calcium lines, and that from the Magnesium line.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
May 17, 1909.

WATER VAPOR AND OXYGEN ON MARS

By C. A. Chant

OUR interest in Mars is perennial. The scientific investigator assiduously studies the markings on its surface, the peculiarities of its spectrum and any other features which he can observe. From his point of view the problems presented by Mars are of the very highest importance ; while to the general public the question of the planet's habitability, and the attempts to obtain evidence of life on it, are of surpassing interest. If animated beings, at all comparable to those on the earth, exist on any other planet it is on Mars that we would expect to find them.

Our knowledge of Mars is obtained in two ways, (1) by scrutiny of the planet's disc, visually and by photography ; (2) by securing information regarding the constitution and condition of its atmosphere by means of the spectroscope.

Evidence obtained along both of these lines has been recently published, and it is my intention to sketch the work done on the subject. The chief visual observations and photographs of the planet's disc have been made at the Lowell Observatory, at Flagstaff, Arizona, though some excellent photographs have been made by Barnard at the Yerkes Observatory. The general appearance of the disc has become well known, but it is unfortunate that there is not perfect concordance among all the competent astronomers who have reported their observations. All agree regarding the main markings, but with respect to the finer ones, —the so-called " canals," — while some experienced and trustworthy observers unhesitatingly state that they have seen them, others, recognised everywhere as possessing the highest ability and skill, are quite unable to observe them.

Of course the reason for this discrepancy in the evidence is that the objects to be observed are very near the limit of

vision, and though it is certainly regrettable that there is not perfect agreement, the positive evidence is so abundant and in the main consistent, that the negative results can hardly discredit it.

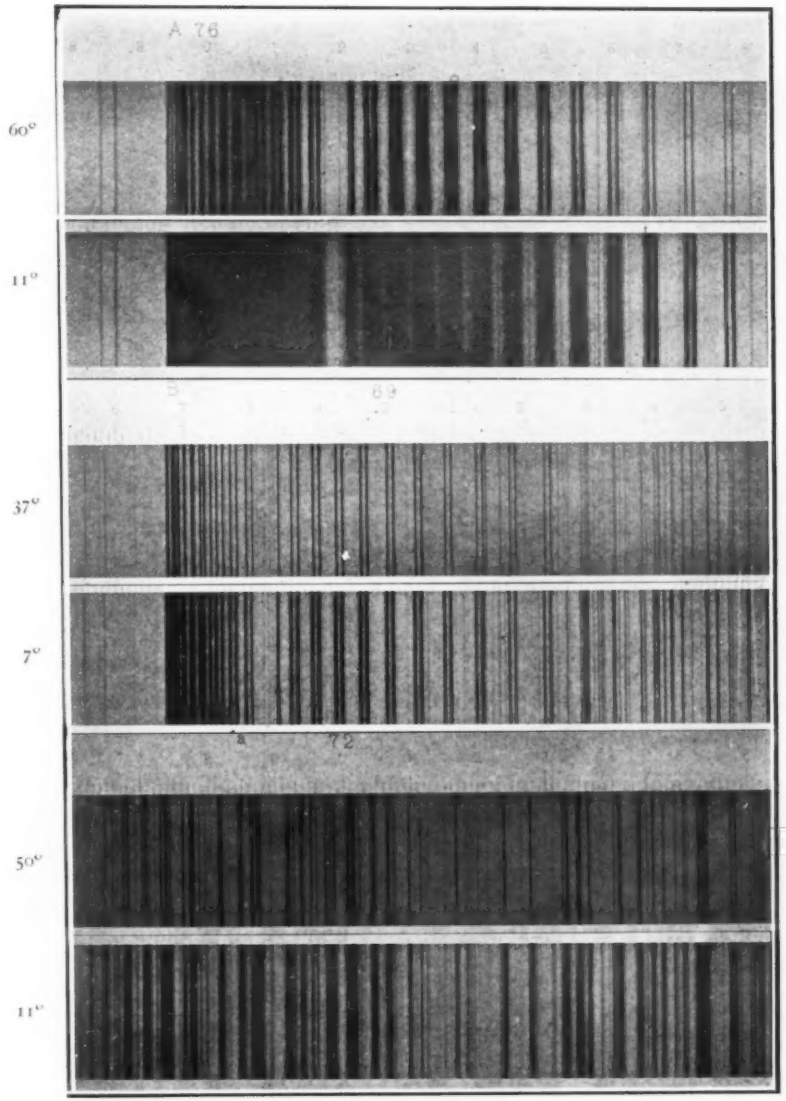
Investigations into the nature of the spectrum of Mars have been made by several eminent spectroscopists. The object usually sought is to secure evidence regarding the presence of oxygen and water-vapor in the planet's atmosphere. These substances are prime requisites for our existence on the earth; and if it can be demonstrated that they are found on Mars, this would be considered evidence tending to confirm the hypotheses advanced by some astronomers that the polar caps are of snow, that the "canals" are probably water-courses and that sentient beings live on the planet. But whether we allow these speculations to influence us or not, the problem of determining the presence of these substances is one of absorbing interest.

When the light from an ordinary gas, oil or electric lamp is examined by means of the spectroscope we find that the spectrum consists of a bright colored band extending from the red at one end through all the intermediate colors, without a break, to the violet at the other end. Such a spectrum is said to be *continuous*. It is given by all incandescent solids and liquids. In the gas and the oil flame it is due to incandescent particles of solid carbon.

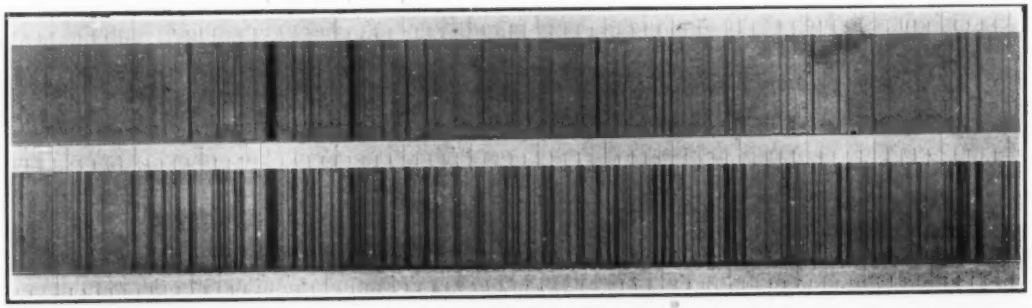
Now when sunlight is examined its spectrum is crossed transversally by a multitude of dark lines. The light which we would expect to find where these dark lines are, has undoubtedly been abstracted or absorbed by some medium through which the light has passed. The light from the interior of the Sun would, without doubt, give a continuous spectrum, and the chief medium through which it must pass is the Sun's atmosphere, and it is believed that these dark lines are due to absorption in that medium. Indeed a comparison of these lines with those given in our laboratories by incandescent gases have revealed the clue to their meaning. They demonstrate the presence in the Sun's atmosphere of many of the elements known to us on the earth.

These dark lines in the spectrum are then due to absorption.

PLATE XX.



Photographs of the *A*, *B*, and *a* bands taken when the Sun was high and when low. The altitude is given in degrees. The much greater intensity of the lines when the Sun is low is due to the greater absorption by the earth's atmosphere.



Photograph of the solar spectrum in the neighborhood of the D lines with the Sun at altitudes 13° and 1°. The so-called "rain-band" is shown in the lower portion.

(This and the previous plate are taken from Higgs's Photographs of the Solar Spectrum).

But before reaching us the sunlight must also pass through the atmosphere of the earth, and during the passage we would expect further absorption. Such is the case. Our atmosphere causes a general absorption, which diminishes the brightness of the spectrum as a whole, but in addition to this it exerts a *selective* absorption which introduces at least 1200 additional dark lines in the spectrum. The fact that these belong to the earth and not to the Sun can be shown in several ways, some of them very ingenious and delicate.

When the Sun is near the horizon its light on its way to us traverses a much greater mass of the atmosphere than when it is high in the sky, and hence in the former case the atmospheric absorption or *telluric* lines should be more numerous and marked. This is well shown in the photographs reproduced in Plates XX. and XXI.

Amongst the many absorption lines there are three strong groups known as the *A* (λ 7594), *little a* (λ = 7175) and *B* (λ = 6867) bands. These are produced by water-vapor—perhaps chiefly by the oxygen in it—and the presence of these bands in the spectrum of a planet would indicate the presence of an atmosphere.

Now Mars is not self-luminous, but is visible by reflected sunlight, and that light on its way to us must pass through the Sun's atmosphere, twice through the planet's atmosphere and finally through our own. Thus the spectrum of Mars is a compound one, due to the atmospheres of the Sun, the planet and the earth, and if there is no atmosphere on the planet the spectrum should be identical with that due to the solar and terrestrial atmospheres together.

All agree that the atmosphere of Mars must be thin, and, indeed, its effect is so slight that the problem of investigating it would hardly admit of solution if we had not at hand a convenient object with which to compare it. That object is our Moon. The atmosphere of our satellite is inappreciable, and hence if the spectra of the Moon and of Mars when obtained under identical

conditions are indistinguishable we would infer that the atmosphere of Mars, like that of the Moon, is practically negligible.

Let us review some of the evidence on the question.

Janssen in a letter to the French Academy in 1867 says; "I cannot bring this letter to a close without telling you that I have ascended Mt. Etna for the purpose of making some spectroscopic observations which require a great altitude in order to annul the greater part of the influence of our atmosphere. From these observations and from those which I have made at the Observatories of Paris, Marseilles and Palermo, I believe I can announce to you the presence of aqueous vapor in the atmospheres of Mars and Saturn."

In the same year Huggins observed in the spectrum of Mars, lines "apparently coincident with groups of lines which make their appearance when the Sun's light traverses the lower strata of the [earth's] atmosphere, and which are, therefore, supposed to be produced by the absorption of gases or vapors existing in our atmosphere. The lines in the spectrum of Mars probably indicate the existence of similar matter in the planet's atmosphere."

Secchi in 1872 stated that he considered that his observations "proved the existence of a Martian atmosphere analogous to our own."

In 1874 Vogel published his great monograph on the spectra of the planets, in which he says, "it is definitely settled that Mars has an atmosphere whose composition does not differ appreciably from ours, and, especially, the Martian atmosphere must be rich in aqueous vapor."

Observations by Maunder at Greenwich in 1877 confirmed in general the results of Vogel.*

Thus the evidence of these competent spectroscopists all pointed to the conclusion that Mars has an atmosphere similar to our own, and that conclusion was quite generally accepted until

*The above references are contained in Campbell's paper on "The Spectrum of Mars," in *Publications of the Astronomical Society of the Pacific*, No 37, and *Astronomy and Astrophysics*, Vol. XIII., p. 752, 1894.

it was sharply questioned in 1894 by Campbell of the Lick Observatory.

On examining the conditions under which the observations had been made, Campbell found that they were generally very unfavorable, and as the summit of Mount Hamilton, at an elevation of 4200 feet, with low humidity, is above much of the earth's atmosphere, he determined to re-examine the whole question.

He worked chiefly between $\lambda\lambda$ 653-660 and $\lambda\lambda$ 646-652. He observed the spectrum of Mars on ten nights between June 29 and August 10. On eight nights he compared its spectrum with that of the Moon when the two bodies were at nearly equal altitudes. On two nights when the Moon was near the planet he turned repeatedly from one spectrum to the other. Every care was taken to have the two spectra equally bright, equally wide and, indeed, as nearly as possible under identical conditions.

The results of his observations he gives as follows :—

" *First.*—The spectra of Mars and our Moon, observed under favorable and identical circumstances, seem to be identical in every respect. The *atmospheric* and *aqueous vapor* bands which were observed in both spectra appear to be produced wholly by the elements of the Earth's atmosphere. The observations furnish, therefore, no evidence whatever of a Martian atmosphere containing aqueous vapor.

Second.—The observations do not prove that Mars has *no* atmosphere similar to our own ; but they set a superior limit to the *extent* of such an atmosphere. Sunlight coming to us *via* Mars would pass twice, either partially or completely, through this atmosphere. If an increase of 25 to 50 per cent. in the thickness of our own atmosphere produces an appreciable effect, a possible Martian armosphere one-fourth as extensive as our own ought to be detected by the method employed.

Third.—If Mars has an atmosphere of appreciable extent, its absorptive effect should be noticeable *especially* at the limb of the planet. My observations do not show an increased absorption at the limb. This portion of the investigation greatly

strengthens the view that Mars does not have an *extensive* atmosphere.

While I believe that the polar caps of Mars are conclusive evidence of an atmosphere and aqueous vapor, I do not consider that they exist in sufficient quantity to be detected by the spectroscope. This view has an important bearing upon the questions relating to the low albedo of the planet, and the well-known brightness of its limb, in both of which respects the planet resembles our Moon."

These contradictory observations by Campbell led Sir William and Lady Huggins and Vogel to renew in 1894 their earlier observations, and they reported again that they were satisfied that the spectrum of Mars showed evidence of absorption due to its own atmosphere. However, as Campbell's work was done under favorable conditions, his results disturbed the confidence which had been placed in the earlier observations. Indeed, Vogel, writing in 1895, says,* "I believe it will be necessary to wait for still further observations, perhaps also those made from another point of view, before the question can be definitely settled."

Up to this time the observations had been entirely visual, and it was felt that the application of photography would eliminate many of the difficulties. However, since it was necessary to photograph the red-end of the spectrum, the plates used early were poor for the purpose. Campbell in 1895 and Keeler in 1897 tried the photographic method but with negative results.

By 1905 plates much more sensitive to the red end of the spectrum were obtainable and spectrograms of Mars were made at the Lowell Observatory, but the results were still indecisive. The great improvements recently made in the preparation of suitable plates encouraged further attempts at the problem. The results of these we shall now see.

The Lowell Observatory, located at Flagstaff, Arizona, is 7,250 feet above the sea-level, is surrounded by desert or semi-

*See Slipher, *The Spectrum of Mars; Astrophysical Journal*, Vol. XXVIII., p. 397, 1908.

desert, and the air is very dry. During January and February, 1908, at which time of the year the amount of water vapor in the earth's atmosphere is very small, a series of photographs of the spectra of Mars and of the Moon, under precisely similar conditions were taken by Dr. V. M. Slipher on plates bathed in a special solution of dyes which rendered them quite sensitive down to λ 7000. The *little a* band was very prominent. Under the conditions chosen the photographs were taken through about one-fifth as much vapor as would have been encountered by an observer working at sea-level at the same temperature.

Dr. Slipher states: "The results of the examination of these plates lead to the conclusion that the *a* band is re-inforced in *Mars* due to absorption in its atmosphere. Although some of the plates may be indecisive, the majority asserts this and none deny it. In general, those that show little or no difference; exhibited by their lunar images strong terrestrial absorption, and those that show a marked difference exhibit weak terrestrial absorption. In other words, the delicate Martian component is easily masked by the terrestrial one and apparently cannot show unless the latter is very weak.

Since this band in the spectrum of the earth's atmosphere has been found to be due to absorption by aqueous vapor and it appears to be identical in the two spectra except for the difference in strength, the reasonable conclusion is that the spectrograph has revealed the presence of water in the atmosphere of Mars."

Accompanying Dr. Slipher's paper are reproductions of the spectra of Mars and the Moon which certainly seem to bear out his conclusion.

Some of the spectrograms taken at the Lowell Observatory were placed in the hands of Professor F. W. Very, a former worker in astrophysics with the late Professor Langley, and in Lowell's Observatory *Bulletin*, No. 36, (See also *Science* for January 29, 1909,) he describes measurements which he had made of the intensification of the *little a* band in the spectrum of Mars. Mr. Very used an instrument called a spectral band comparator,

devised by himself, by which he was able to measure the intensity of the bands in the spectrum of Mars. He says* :—

"Differences of illumination which we note immediately, but which are not judged to be great, which in fact, at first guess, we estimate as but a few per cent. turn out to be many hundred per cent. when made the subject of exact measurement. It is probable that very few would guess in the absence of exact measurement that a first-magnitude star is one hundred times as bright as a sixth-magnitude. Bearing these facts in mind, it need excite no surprise when I state that the actual ratio of intensity of the *a* band in Mars, when expressed in absolute units, is much greater than would at first be inferred from the direct readings. I find that the real intensity of the band in the spectrum of Mars in the month of January, when the dew-point at Flagstaff was about 20° F., was *four and a half times as great* as in the lunar spectrum at the same altitude.

"Admitting that the *little a* band is four and one-half times as intense in the spectrum of Mars, if we may assume that the intensity of the band is proportional to the total amount of vapor present in the combined air columns traversed by the rays, as it is very nearly in the case of incipient absorption, it is perhaps permissible to say, since the rays pass twice through the atmosphere of Mars, that on the average Mars has $0{\cdot}5 \times (4{\cdot}5—1{\cdot}0) = 1{\cdot}75$ times as much aqueous vapor in its atmosphere as that which exists above Flagstaff in the month of January, or roughly, since one and three-quarters times the amount of water vapor in the surface air of Flagstaff would be 2·17 grains per cubic foot, or 5·0 grams per cubic meter, it may be concluded that the dew-point on Mars would be 33° F., if the distribution of moisture were the same in the upper air of the two planets."

In the Lowell Observatory *Bulletin*, No. 41, Mr. Very describes further measurements which he has made on the Lowell spectrograms, this time chiefly on the *B* band, which is believed to be due to oxygen. In *Science* for November 12, 1909, is an interesting summary of his work, which closes as follows :—

* *Science*, Jan. 29, 1909, p. 192-193.

"Eight entirely independent series of measures were made on four plates, each containing three spectrograms. No computations were made until after the last measurement had been completed, and I had no knowledge whatever of the significance of the result until the computations were finished. Since every one of the eight series gave a positive result, and since the method was so guarded as to eliminate every source of possible error which is known to me, I have no hesitation in announcing the intensification of great *B* in the spectrum of Mars as a fact. Nevertheless, I must warn any one who seeks to repeat the observation that its verification will demand exceptional facilities, a long apprenticeship in the art of delicate photometric comparisons, and a good deal of patience and persistence. The measurement is much more difficult than the by no means easy one of the intensification of the *little a* band of water vapor in Mars. In illustration of the difficulty of the latter observation, I may say that in trying to demonstrate it to visitors, the first objection is apt to be, 'but I don't see any band.' When, after some coaching, the faint hazy band is seen, the next assertion is usually that there is no difference in its intensity in different spectra; and it is hopeless to expect a verification of the delicate quantitative measurement, unless the would-be observer can acquire the requisite skill. It is important that the spectrograms of the water-vapor band shall be secured when the water vapor in the *total* terrestrial air column is in smallest quantity. A low dew-point at the earth's surface does not guarantee this condition, which, in general, is almost never present in summer. For this reason the spectroscopic data should be obtained in winter."

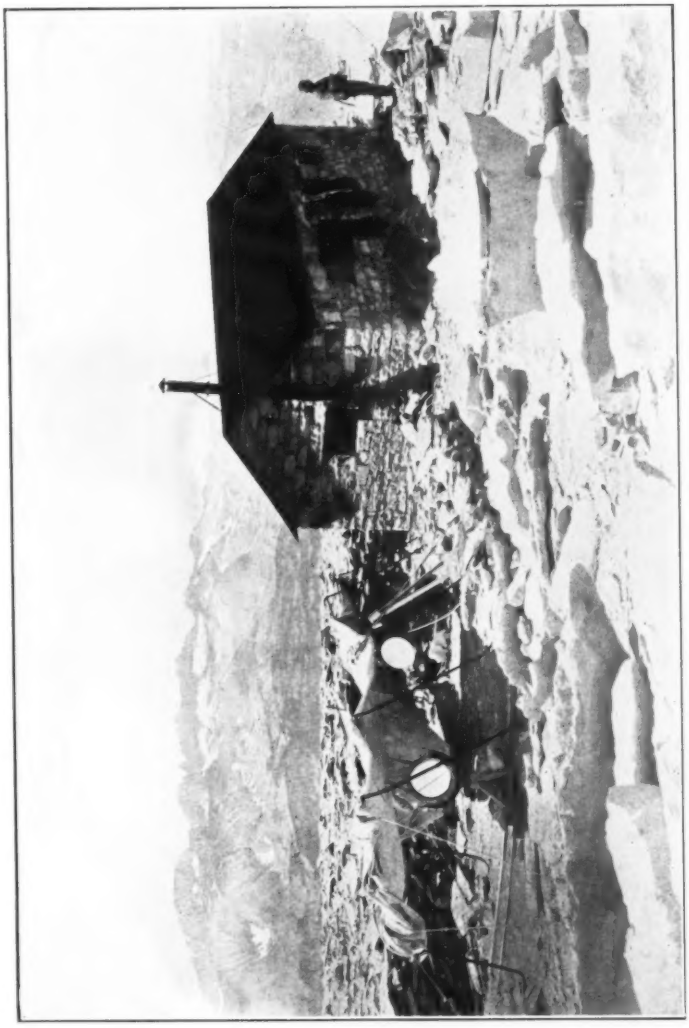
Thus the evidence seemed decisively to show the presence of oxygen and water vapor on Mars. The matter was not allowed to rest here, however. In August of this year an expedition from the Lick Observatory, which had been planned years before, ascended Mount Whitney, the highest point of land in the United States, and made observations on the spectra of Mars and the Moon. Director Campbell gives an interesting account of the expedition in the *Publications of the Astronomical Society of the*

Pacific (October, 1909,) from which the following account is taken :—

" When the spectrum of Mars was under observation extensively at Mount Hamilton in 1894, for the purpose of detecting the presence of water vapor in that planet's atmosphere, I realized that the water vapor in the Earth's atmosphere was and is the great obstacle in the way of success ; and I then resolved to observe the spectrum of Mars from the summit of Mount Whitney,* the highest point of land in the United States, when the planet should again come into a position favorable for the purpose. This would occur in August-September, 1909, when Mars would be near the Earth and high above the horizon at the time of year when Mount Whitney could be ascended with instruments.

Late in August, 1908, I ascended Mount Whitney, in order to determine the limiting sizes of instruments which could be transported over the rocky trail on the backs of the pack animals, and to plan the living arrangements for the proposed expedition of 1909. I was accompanied by Director C. G. Abbot, of the Smithsonian Institution Observatory, who was interested in the summit of Mount Whitney in connection with high-altitude studies of solar radiation, as Professor Langley's pioneer expedition had been interested in 1881. We remained on the summit throughout the night of August 24, 1908. The readings of the dry and wet-bulb thermometers obtained by Director Abbot indicated that the conditions were extremely favorable for the solution of the proposed problem. Before leaving the summit I decided definitely that observations in 1909, requiring a residence of a week or more, should not be undertaken unless a building of some kind could be erected as a shelter in case of storm ; and the question of ways and means were discussed. Director Abbot suggested that the purposes of such a building might, perhaps, come within the scope of the Hodgkins Funds of the Smithsonian Institution. A few weeks later, after receiving my description

*In the Sierra Nevada Mountains, California. Longitude, 118° 18′ W.; latitude, +36° 35′; altitude, 4,420 meters (14,501 feet).



THE SHELTER ON THE SUMMIT OF MOUNT WHITNEY AND THE LICK OBSERVATORY INSTRUMENTS

of a building which would meet the needs of the proposed expedition, he was pleased to present the subject to Dr. C. D. Walcott, Secretary of the Smithsonian Institution, for consideration. Through the Secretary's lively interest, an appropriation to provide the building for the shelter of the 1909 and any worthy future expeditions was made.

As soon as the shelter was assured, Honorable William H. Crocker, Regent of the University of California, made generous private provision for all the expenses of the expedition from the Lick Observatory, University of California, including such pieces of new apparatus as were required to complete the equipment. This expedition was on the summit of Mount Whitney from August 28 to September 4, 1909. The instruments consisted of a 16-inch horizontal reflecting telescope and a suitable spectroscope. The observations, made on the nights of September 1 and 2, were mainly photographic.

The building erected by the Smithsonian Institution, under the supervision of Mr. G. F. Marsh, a public-spirited citizen of Lone Pine, was finished on the morning of our arrival. Its outside dimensions are eleven feet by thirty feet, and it is divided into three rooms. It has walls of stone and cement, door and roof of steel, and windows of steel and wire-plate glass. No wood or other perishable material was used in its construction.

The Crocker Expedition had abundant reason to appreciate the protection afforded by the building, as severe storms were encountered on the summit.

Water vapor in the atmosphere of any planet causes dark bands to be formed at certain definite positions in the spectrum of that planet; conspicuous bands if the water vapor is abundant; inconspicuous bands if the quantity is slight, as this, the only method known, is not a sensitive one.

The observer of Mars must look up through the earth's atmosphere; and the great quantity of water vapor in our atmosphere, if the observer is near sea level or at ordinary altitudes, blots out the effect of any Martian vapor, making a solution of the problem impossible. By ascending Mount Whitney, altitude

14,501 feet, the Crocker Expedition placed itself above probably four-fifths or more of the earth's water vapor. Further, the air on Mount Whitney was astonishingly dry during the time of the observation. With barometer 17⅔ inches, air temperature 29° Fahrenheit, and wet thermometer 17°, students of the atmosphere will recognize that the observers of Mars were looking through remarkably little terrestrial water vapor. Even this small quantity would be almost fatal to success if we did not have a fairly satisfactory method of eliminating its effects, as follows: Our Moon has no appreciable atmosphere. The lunar and Martian spectra will be affected alike by the water vapor in the earth's atmosphere. These spectra are photographed, one immediately after the other while the conditions in our atmosphere remain unchanged, and with the Moon and Mars at the same altitude above the horizon so that their rays traverse equal paths in our atmosphere. If the vapor bands in the Martian spectrum are found to be stronger than in the lunar spectrum, Mars has water vapor in considerable quantities. If the bands in the two spectra are estimated to be equally strong, water vapor on Mars, does not exist in sufficient quantities to be detected by the spectroscopic method. The latter condition was found to exist, when this method was applied under the superlatively favorable conditions existing on Mount Whitney. Both spectra were photographed when Mars and the Moon were near the horizon, again when they were at medium altitudes, and finally when they were 49° above the horizon. The best available vapor band, technically called "*a*," was faint in both spectra when the bodies were low, fainter when the bodies were higher, and very faint when the bodies were at their highest; but for equal altitudes the "*a*" bands in the Martian and lunar spectra were equally intense, plainly signifying that the observed bands were due to water vapor in the Earth's atmosphere above the summit of Mount Whitney. This does not mean that Mars has no water vapor, but only that the quantity present, if any, must be very slight. Let us recall that we see Mars by reflected sunlight. The rays which reached our instruments passed from the

Sun into the Martian atmosphere, for the most part down to the surface of the planet, and then out again to us, thus passing twice through the planet's atmosphere and any water vapor it may contain. Even with this multiplying effect on Mars the vapor bands in the Martian and lunar spectra were alike, and we conclude that any water vapor in the Martian atmosphere must have been less extensive than was contained in the rarefied and remarkably dry air strata above Mount Whitney.

A detailed account of the Crocker Expedition, including descriptions of the spectra as photographed, and a discussion of the results obtained are in press as a *Lick Observatory Bulletin*.

The members of the party were Director W. W. Campbell, Assistant Astronomer Sebastian Albrecht, and Carpenter Hoover, of Lick Observatory ; Dr. John J. Miller, of San Jose, who took charge of all questions relating to health ; and Messrs. G. F. Marsh and W. L. Skinner, of Lone Pine, California."

Thus, after all this careful work we are left in as much doubt as ever regarding this problem. What the next evidence will be it is difficult say. It will certainly be examined with great interest.

HALLEY'S ACCOUNT OF HIS INVESTIGATIONS ON THE ORBITS OF COMETS.

HALLEY'S treatise, which bore the title "Astronomiæ Cometicæ Synopsis," (*i. e.* "A Synopsis of the Astronomy of Comets") was presented to the Royal Society in 1705, and was published in 1706 in volume 24 of the Society's *Transactions*, pages 1882-1899. The following account of this work is taken from Volume IV. of Baddam's abridgment of the Memoirs of the Royal Society (London, 1739). The original spelling, punctuation and italics are retained here.

The ancient *Egyptians* and *Chaldeans* (if we may credit *Diodorus Siculus*) being furnished with a long series of observations, could predict the rising, or appearing of comets; but since, they also are said by the same arts to have foretold earthquakes and tempests, it is past all doubt, that their knowlege in these matters was rather the result of astrological calculations than of astronomical theories of the motions of the celestial bodies; and the *Greeks*, who were the conquerors of both these nations, scarcely found any other sort of learning among them than this; so that it is to the *Greeks* themselves, as the inventors, especially to the great *Hipparchus*, that we owe this astronomy, which is now so greatly improved; but *Aristotle's* opinion (*viz.* that comets were nothing else than sublunary vapours or airy meteors) prevailed so far amongst the *Greeks*, that this sublimest part of astronomy lay altogether neglected; since none could think it worth while to observe, and give an account of the wandering and uncertain paths of vapours floating in the *Æther*; whence it is, that we have nothing certain handed down from the ancients concerning the motion of comets; but *Seneca* the philosopher, considering the *Phænomena* of two remarkable comets of his time, made no

scruple to place them amongst the celestial bodies, taking them to be stars of equal duration with the world itself; tho' he owns, that their motions were regulated by laws not then discovered; at length, he foretels (which has proved no vain prediction) that time and diligence would unfold these mysteries to some future ages, who would be surpris'd how the ancients could be so ignorant of them, after that some lucky interpreter of nature would have pointed out in what parts of the heavens comets wandered, and shewn what, and how great they were; yet almost all astronomers differed from *Seneca* in this; and *Seneca* himself has not left any account of the *Phænomena* of the motion, whereby he might support his hypothesis, nor assigned the time of their appearing, which might enable posterity to determine any thing in this matter: So that after Mr. *Halley* had turned over several histories of comets, he could find nothing at all, that could give any assistance herein, before *A. D.* 1337, when *Nicephorus Gregoras*, an historian and astronomer of *Constantinople*, had pretty accurately described the path of a comet amongst the fixed stars; but he too loosely assigns the time, so that this undetermined comet only deserved to be inserted in the catalogue, on account of its having appeared almost 400 years ago; the next comet *A. D.* 1472, which moved the swiftest of all, and came nearest to the earth was observed by *Regiomontanus*; this comet (so frightful on account both of the magnitude of its body and its tail) in the space of a day moved 40° of a great circle in the heavens, and it is the very first of which, any proper observations have been handed down to us; for all those who considered comets before *Tycho Brahe*, that great restorer of astronomy, supposed them to be below the moon, and so took but little notice of them, imagining them to be no other than vapours: But in the year 1577 *Tycho Brahe* applying himself seriously to the study of astronomy, and having procured large instruments for making celestial mensurations, with greater exactness and certainty than the ancients could ever hope for; there appeared a pretty remarkable comet, to the observation of which *Tycho* vigorously applied himself, and he found by several unquestion-

able trials, that it had no sensible diurnal parallax ; and consequently, that it was not only no aerial vapour, but much higher than the moon ; nay, and might be reckoned amongst the planets for anything that appeared to the contrary, notwithstanding the cavilling opposition of some schoolmen ; to *Tycho* succeeded the sagacious *Kepler*, who having the advantages of *Tycho's* observations, found out the true and physical system of the world, and vastly improved astronomy ; for he demonstrated, that all planets revolved in planes passing through the centre of the sun, and describing elliptical curves, observing this law, that the area's of the elliptic sectors taken at the centre of the sun, in the *Focus* of the ellipsis, are always proportional to the times, wherein the corresponding arches are described ; he also discovered, that the distances of the planets from the sun are in the sesquialteral ratio of their periodical times, or that the cubes of the distances are as the squares of the times ; this great astronomer had the opportunity of observing two comets, one of which was very remarkable ; and from his observations of these, he concluded, from several indications of an annual parallax, that comets move freely thro' planetary orbits, with a motion not much different from a rectilinear one, but which he could not determine : Next *Hevelius*, a noble emulator of *Tycho*, following *Kepler's* steps, embraced the same hypothesis of the rectilinear motion of comets, he himself having very accurately observed several of them ; yet he complained, that his calculations did not altogether agree with the appearances in the heavens, and he was aware that the path of comets was incurvated towards the sun : At length, that extraordinary comet of 1680 descended from a vast distance, and as it were, in a perpendicular line towards the sun, and ascended from him again with an equal velocity ; this comet appearing constantly for four months, by the peculiar and remarkable curvity of its orbit, seemed above all others the most adapted for investigating the theory of their motion ; and the Royal observatories at *Paris* and *Greenwich* being founded some time before, and committed to the care of the most famous astronomers, the apparent motion of this comet was (as far as human sagacity could reach)

very accurately observed by M. *Cassini* and Mr. *Flamstead*: Not long after, that incomparable geometrician Sir *Isaac Newton*, not only demonstrated that what *Kepler* had found, did necessarily obtain in the planetary system, but likewise that all the *Phænomena* of comets plainly follow from the same principles, which he fully illustrated by the above-mentioned comet of 1680; and at the same time shewed the way of geometrically constructing the orbits of comets, and to the surprise of all men, solved a problem, whose intricacy rendered it worthy of so great a genius; and he proves that this comet revolved round the sun in a parabolic orb, in such a manner that the areas estimated at the centre of the sun were proportional to the times: Mr. *Halley* pursuing the steps of so great a man, attempted (and he presumes not without

THE ASTRONOMICAL ELEMENTS OF THE MOTIONS, IN A PARABOLIC ORBIT, OF ALL THE COMETS HITHERTO OBTAINED

Passage of Perihelion London Time				Longitude of Perihelion		Longitude of Asc. Node		Inclination of Orbit		Distance from Sun at Perihelion
	d	h	m	°	′	°	′	°	′	
1337, June	2	6	25	37	59	84	21	32	11	·40666
1472, Feb.	28	22	23	45	34	281	46	5	20	·54273
*1531, Aug.	24	21	18	301	39	49	25	17	56	·56700
1532, Oct.	19	22	12	111	7	80	27	32	36	·50910
1556, Apr.	11	21	23	278	50	175	42	32	6	·46390
1577, Oct.	26	18	45	129	32	25	52	74	33	·18342
1580, Nov.	28	15	00	109	6	18	57	64	40	·59628
1585, Sept.	27	19	20	8	51	37	42	6	4	1·09358
1590, Jan.	29	3	45	216	54	225	31	29	41	·57661
1596, July	31	19	55	228	15	312	12	55	12	·51293
*1607, Oct.	16	3	50	302	16	50	21	17	2	·58680
1618, Oct.	29	12	23	2	14	76	1	37	34	·37975
1652, Nov.	2	15	40	28	19	88	10	79	28	·84750
1661, Jan.	16	23	41	115	59	82	30	32	36	·44851
1664, Nov.	24	11	52	130	41	81	14	21	18	1·02576
1665, Apr.	14	5	16	71	54	228	2	76	5	·10643
1672, Feb.	20	8	37	47	0	297	30	83	22	·69739
1677, Apr.	25	00	38	137	37	236	49	79	3	·28059
1680, Dec.	8	00	6	262	40	272	2	60	56	·00612
*1682, Sept.	4	7	39	302	53	51	16	17	56	·58328
1683, July	3	2	50	85	30	173	23	83	11	·56020
1684, May	29	10	16	238	52	268	15	65	49	·96015
1686, Sept.	6	14	33	77	0	350	35	31	22	·32500
1698, Oct.	8	16	57	270	51	267	44	11	46	·69129

(Those marked with a star * are successive apparitions of Halley's Comet).

success) to bring the same method to an arithmetical calculation; for having collected together all the observations of comets, he obtained the foregoing table, the result of almost immense calculation.

[Then follows *A general table to compute the Motion of Comets in a parbolic Orbit*, together with an explanation of its construction and use].

It is to be observed that the five first comets, the third and fourth of which was seen by *Petrus Apianus*, and the fifth by *Paulus Fabricus*, as was the tenth by *Mestlinus* in the year 1596, have not the same degree of certainty with the rest, the observations not having been made with the proper instruments or the necessary exactness, and therefore, disagreeing with each other, they can by no means be reconciled with a regular calculation; *Blanchini* alone observed at *Rome* the comet *Anno* 1684; and the astronomers at *Paris* the last comet in 1698, whose path they have described in an unusual manner; this very obscure comet, tho' swift and pretty near the earth, escaped our observations: Mr. *Halley* forbore to insert into his catalogue the two remarkable comets that appeared, the one in *November* 1689, and the other in February 1702, for want of observations; for directing their course towards the southern part of the world, and being scarcely visible in *Europe*, they were not observed by persons equal to the task: It is to be observed that 11 of the comets in Mr. *Halley's* catalogue moved direct, *i. e.* according to the order of the signs; *viz.* those in the years 1532, 1556, 1580, 1585, 1618, 1652, 1661, 1672, 1680, 1684 and 1686; and that the other 13 were retrograde, *i. e.* moved contrary to the order of the signs.

Upon weighing all these things, and comparing the rest of the elements of the motions of these comets with each other, it will appear, that their orbits are disposed in no certain order: and that they are not confined like the planets to the zodiac, but that they move indifferently, every way both retrograde and direct; whence it is plain, that they are not moved by *Vortices*: the distances of this *Perihelia* are found to be sometimes greater and sometimes less; whence we have reason to suspect, that

there are a great many more comets, which being at remote distances from the sun, and being obscure and without a tail, may for that reason escape our observation.

We have hitherto considered the orbits of comets as perfectly parabolic, from which supposition it would follow, that comets, being impelled by a centripetal force towards the sun, do descend from infinite distances, and by their fall acquire so great a velocity, as to convey them into the remotest spaces of the system, and by a perpetual *Nisus* tending upwards, never afterwards to return again to the sun; seeing then that the appearing of comets is very frequent, and that none of them is found to move in an hyperbola, or with a greater velocity than it would acquire in falling towards the sun, it is more credible, that they revolve about the sun in very excentric orbits, and return after very long periods; for, thus their number is definite and perhaps not so very great; and the spaces between the sun and the fixed stars are so immense, that there is room for a comet to perform its period, however large it may be: for the *Latus rectum* of an ellipsis is to the *Latus rectum* of a parabola, having the same *Perihelian* distance, as the *Aphelian* distance in the ellipsis is to its whole axis; but the velocities are in the sub-duplicate ratio of the same: wherefore, in very excentric orbits, this ratio approaches very nearly to a ratio of equality, and the small difference which arises on account of the greater velocity in a parabola, is very easily compensated in determining the situation of the orbit; therefore, the principal use of the elements of the motions in this table is, that whenever a new comet appears, we may by comparing the elements, know whether it is one of those that formerly appeared; and consequently, we may determine its period, and the axis of its orbit, and foretel it return; and Mr. *Halley* tells us that he had several reasons to induce him to believe, that the comet in 1531, which was observed by *Apian*, was the same with that decribed in 1607 by *Kepler* and *Longomontanus*, and which he himself had seen and observed upon its return again in 1682; all the elements agree, and there is no other difference than the inequality of their periods; which yet

is not so considerable, as that it may not be ascribed to physical causes ; for *Saturn's* motion is disturbed in such a manner by the other planets, especially *Jupiter*, that its periodical time is for some whole days uncertain ; how much more may a comet be subject to such irregularities, whose orbit rises almost four times higher than *Saturn's*, and whose velocity, tho' never so little augmented, may change its orbit from an ellipsis to a parabola ; that it was the same comet, is farther confirmed, from that observed, in the summer of 1456, to pass retrograde, almost in the same manner, between the sun and the earth ; which tho' it was not observed astronomically by any, yet Mr. *Halley* conjectures, that was the same with the former, from its period and the manner of its transit ; whence he ventures to foretel its return in 1758, and if this happens, there will be no further cause to doubt, but that the rest may likewise return ; astronomers will therefore have a large field. to exercise themselves in for several ages, before they can determine the number of so many and so great bodies that revolve round the common centre of the sun, and reduce their motions to certain rules : Mr. *Halley* was apt to believe, that the comet of 1532 was the same as that observed by *Hevelius* in the beginning of 1661 ; but *Apian's* observations, which are the only ones we have, are too inaccurate, to determine anything certain from them in so nice an affair : Sir *Isaac Newton* delivers a method of constructing the orbits of comets by three accurate observations, *Philos. Natural. Princip. Mathemat. lib.* III. which afterwards Dr. *Gregory* fully and clearly illustrated in the fifth book of his physical and geometrical astronomy.

Here one thing is to be observed, *viz.* that some of these comets have their nodes so near the annual orbit of the earth, that should it happen at the time of the return of a comet, that the earth was near its node, whilst the comet passes with an incredible velocity, it would also have a very sensible parallax, and which would be to the sun's parallax in a given ratio ; whence, upon such like transits, there would be a very favourable opportunity (which yet seldom happens) of determining the distance of the sun from the earth ; which hitherto could be con-

cluded but very loosely, and that only by means of the parallax of *Mars* in opposition to the sun, or that of *Venus* in the *Perigæum:* and tho' indeed it is thrice greater than the parallax of the sun, yet it is scarcely perceptible with any instrument, and this use of comets was suggested by the famous geometrician *Nio Facio;* for the comet of the year 1472 had a parallax 20 times greater than that of the sun; and had the comet *Anno* 1618 arrived, about the middle of *March* at its descending node, or had the comet *Anno* 1684 come a little sooner to its ascending node, being very near the earth they would have had still more sensible parallaxes; of all the comets there were none that approached nearer the earth than that *Anno* 1680; for, upon a calculation, it was no further distant towards the north from the annual orbit, than the sun's semi-diameter (or the radius of the moon's orbit, as Mr. *Halley* supposes) and that too in November 10th 1^h 6^m P.M.; at which time had it been in conjunction with the earth as to longitude, there might have been observed in its motion a parallax equal to that of the moon: Mr. *Halley* leaves it to philosophers to discuss what consequences would arise from the appulse, contact or collision of the celestial bodies, which yet is not altogether impossible.

MEETINGS OF THE SOCIETY

At Toronto

November 9.—Professor DeLury referred to the fact that the Secretary had received an announcement to the Society of the death of Professor Simon Newcomb, and moved that the Secretary be instructed to communicate with Mrs. Newcomb and to convey to her and her family the sympathy of the Society in her great loss, and its high appreciation of Professor Newcomb's splendid services to astronomical science. The motion was seconded by Mr. J. S. Plaskett and carried.

Mr. A. Sinclair read the report of the Librarian, showing valuable additions to the Library within the last fortnight. Particular reference was made to Sir William and Lady Huggins's new book, Volume II., of the publications of the Tulse Hill Observatory, which came to the Society with the compliments of the authors. Mr. Musson referred to the work of Sir William and Lady Huggins and their magnificent contributions to astrophysics. Mr. Muir moved that a vote of thanks be conveyed to Sir William and Lady Huggins for their gift. The motion was seconded by Mr. L. H. Graham and passed.

The paper for the evening was by Mr. J. S. Plaskett, B.A., the subject being an account of the work done at the Dominion Observatory, Ottawa.

The work at the Dominion Observatory may be classified under the following heads :—

(a) Geophysics, embracing terrestrial magnetism, determination of the magnetic declination, dip and horizontal intensity ; determination of the force of gravity in various parts of the country ; and seismology, or the observing, tabulating and discussing of sensitive records of earthquake shocks.

(b) Meridian work, embracing the determination of the latitude and longitude of selected stations throughout the country, the determination and maintenance of accurate standard time, including a system of synchronously controlled electric clocks throughout all the departmental buildings at Ottawa, and the occurate determination of the absolute positions of certain stars by means of the meridian circle.

(c) Astronomical and astrophysical work, embracing the measurement of the position angle and distance of double stars, the position of comets and the time of occultations of stars by the moon. It includes the photography of selected regions of the sky and of comets, and especially the photography of the spectra of stars for the determination of their radial velocity. These latter stars are mostly spectroscopic binaries, and when a sufficiently large number of measurements have been obtained the character of the motion of the component stars around one another can be determined. This division also includes work in solar research, embracing daily photographs of the Sun's surface for determining the size and position of the disturbed regions, such as spots and faculæ, and spectrograms obtained to determine the character and period of the solar rotation, as well as other researches in this important and practical subject.

(d) The delimitation and marking of the international boundaries. This work has been in progress for many years and is being actively prosecuted. Besides marking and re-marking the boundary lines between Canada and the United States, surveys are made and maps prepared of a strip of country on each side of the boundary.

(e) The Geodetic Survey of Canada. This is, perhaps, the most important practical work carried on in connection with the Observatory. It has been in operation about three years, and already a good start has been made for a primary survey of the whole country.

In division (c) the most time is devoted to the determination of the radial velocities of stars, and through them of the elements of the orbits of spectroscopic binaries. Although the Observa-

tory has only been in operation a short time and with a telescope much smaller than any other engaged in this work, it has already accomplished probably as much as any other in the line of determining orbits, having obtained nine out of about forty that are now known, and is now doing more than any other observatory in this work.

Out of the nine orbits determined, several have rather abnormal features, some indicating the presence of three bodies instead of two, and having other interesting characteristics. It is by the continuation of such work, and by the continual additions to our knowledge thus obtained that we may finally hope to obtain a better idea of the construction of the universe, and it is impossible to foretell in advance how great a practical bearing such work may have.

The address was illustrated with many lantern slides showing the splendid equipment of the Observatory, and illustrations of the results of the investigations held there, and was followed by an interesting discussion. A hearty vote of thanks to the lecturer was passed at the close of the meeting on motion of Professor DeLury, seconded by Mr. A. F. Miller, and at considerably past the usual closing hour the meeting adjourned.

November 23.—Mr. A. F. Miller stated that he had observed Mars on every possible occasion during the last few weeks, but that it has now receded so far that the detail visible at the time of opposition cannot be seen with his telescope. He also reported that *Mira* is at present between the 5th and the 6th magnitude.

Rev. Robert Atkinson, of Chesley, who was present, spoke of the pleasure he felt in being present at a meeting of the Society after an absence of several years, and stated that he is still observing with his three-inch telescope.

The paper for the evening was by Mr. Lawrence V. Redman, B.A., and dealt with some recent developments in physics, chiefly in regard to Colloidal Particles.

The history of colloids was reviewed, beginning with the purple of Cassius and gold dissolved in glass. Graham's classification and Faraday's researches were also mentioned. Then

followed Tsigmondy's and Seidentopf's discovery of the ultra-microscope. This new instrument shows particles one-twentieth the size of the smallest seen in the ordinary microscope, and physicists are now working in the hope of using ultra-violet rays and extending the power of the ultra-microscope fifty diameters, which should then show the molecule of hydrogen. The motion of the particles was shown from slides. The Brownian movements and the oscillating motions of the particles were illustrated, showing the resemblance of the moving particles to the motion of the stars. Recent discoveries prove that all bacteria can be treated like colloids in that they are precipitated by the addition of certain quantities of electrolytes. Slides of arsenic sulphide illustrated the recent discoveries of Ostwald in connection with Titian's painting, showing that it was by means of a precipitated colloid used as a base on the canvas and by the superposition of a colloid (in solution) upon this base that such excellent colours were produced by the great painter.

An interesting discussion followed, in which Messrs. R. Atkinson, W. B. Musson and J. R. Collins took part. It was moved by Professor DeLury and seconded by Mr. A. Elvins, that a vote of thanks be tendered to the lecturer for the trouble he had taken in presenting the subject so attractively, and as an expression of the high appreciation of the Society of the value of such an address.

E. D.

At Ottawa

October 11.—The meeting was held in the Normal School, and to a well-filled house Dr. Otto Klotz, the chairman for Ottawa, introduced Professor Edwin B. Frost, of the Yerkes Observatory, who spoke on "Phases of Work in a Modern Observatory."

Prof. Frost prefaced his address by stating that he would show a series of lantern slides exclusively of the Yerkes Observatory, and what he had to say would be in explanation of or in comment upon them.

It would be useless to attempt a verbal report of the slides shown. Inasmuch as they were actual photographs they gave the audience a view of what the astronomer himself sees with the help of his instruments, and were, of course, free from all the exaggeration so common in the sensational statements of many of the popular talks on astronomy. The series of views began with pictures of Yerkes Observatory, its founder and patrons and some of its most distinguished workers. Then followed pictures of the great telescope with its numerous attachments and the other instruments. Finally came pictures, taken by the aid of these telescopes, of the Sun, Moon, the planets, the Morehouse comet, Halley's comet, star clusters, stars, clouds in the Milky Way, and showing the spectroscopic work being done by the Observatory.

In connection with the pictures of the Sun, Prof. Frost said that a recent invention rendered it possible to photograph phenomena outside of the Sun's edge at *any* time: formerly this was possible only at time of a total solar eclipse. Several slides taken in this way showed the "flames" rising from the Sun's limb. Other slides of sun-spots suggested at once to the mind, by the markings about them, that they were centres of magnetic forces. A slide of the Moon was of the sharpness of a bronze casting; and it was pointed out that by a study of the lengths of the shadows on this picture alone, a relief map of the Moon might be made.

Beautiful slides of several of the planets were shown. Those of Mars were noteworthy, not only for what they showed to be on the planet, but also for the negative character of the evidence they presented in that respect.

A series of slides showed how the light of the stars was made to tell us their chemical composition and their motion in the line of sight. The theory of spectroscopic binaries was also illustrated.

At the close a vote of thanks moved by Dr. W. Saunders was heartily endorsed by the audience. After the announcement of the subject for the next lecture, the meeting adjourned.

October 21, 3 p.m.—Mr. J. S. Plaskett read a paper on "Collimation of Correcting Lenses." Mr. Plaskett stated that after the installation of the new spectroscope the spectrum towards the violet end was weaker than could be accounted for by extra absorption through the new prism. It was important that this defect should be remedied, as the lines at the violet end are often necessary for measurement, and, moreover, the cause which brought about this defect might also bring about a displacement of the lines.

First, experiments were made to find whether the slit through which the light passed was placed in the star focus, and whether matters could be improved by moving the correcting lens vertically.

Then attempts were made to ascertain whether the guiding telescope was adjusted properly. To do this, photographs were taken of the spectrum of Vega, first when the guiding telescope indicated the image to be central on the slit and then when it was slightly above and slightly below the slit. In this way the image was shown to be asymmetric with regard to the slit. Further experiments revealed the cause of this; it was finally shown to be due to the collimation of the correcting lens. Mr. Plaskett showed slides illustrating the effect of moving the correcting lens out of collimation by $\frac{1}{100}$, $\frac{1}{50}$ and $\frac{1}{32}$ inch.

It was then found that, owing to flexure, the correcting lens might be in collimation for one position of the instrument but out of collimation for other positions. To overcome this difficulty tests were being made to find the best position of the correcting lens for each position of the instrument; a table would be prepared giving these positions, and by means of a screw with a micrometer head the lens could be properly adjusted as indicated by the table. These experiments were useful also in leading to a knowledge of the best position to keep the image when guiding the instrument.

After discussion on the subject Dr. Klotz thanked Mr. Plaskett in the name of the Society, and then introduced Mr. R.

M. Motherwell, who gave a paper on "Determination of a Comet's Orbit from Three Observations."

An observation on a comet gives its right ascension and declination, or its angular co-ordinates, determining only its direction; its distance and velocity being unknown. Three observations give us six equations to determine six unknown quantities. These six unknowns define the orbit of the comet. The difficulties in solving the equations lie in the fact that the functions are transcendental, involving the elements in a very complicated fashion.

As the three positions lie in a plane passing through the Sun's centre, we have at once a relation existing among the rectangular co-ordinates of the three points. This relation can be written in three different forms having terms involving the projections of the triangles formed by two positions of the comet and the Sun, on the planes of reference. To solve a practical example it is then necessary to make some approximation. Olbers assumes that the triangles above referred to are in area proportional to the times of describing them.

The different steps in the solution were then given by Mr. Motherwell in algebraic form, and the conditions mentioned under which the solution fails on account of some of the quantities becoming indeterminate. In some cases further observations might be necessary. One of the equations used becomes transcendental if the motion is elliptical, in which case another method of solution becomes necessary. To discuss this method would require more time than available at one meeting.

In the discussion Dr. Klotz asked what was the most favorable time to observe a comet, with a view to determining its orbit. Mr. Motherwell replied that he considered the most favorable time to be when the comet and the earth were at equal distances from the Sun, provided, of course, that other conditions were favorable.

November 4, *3 p.m.*—Mr. A. H. W. Cleave was elected a member of the Society.

Dr. Otto Klotz gave an address on "Some Scientific Crumbs from Europe." Dr. Klotz said that he went to Europe as delegate to the International Seismological Conference held at Zermatt, Switzerland; and from there he visited a number of observatories in Germany, afterwards crossing to England on his route back to Canada. He then gave briefly the things of scientific interest which he noted at each place.

Speaking of the Conference itself Dr. Klotz said that twenty countries were represented out of the twenty-three comprising the Association. The most important Committee,—that on "Seismological Instruments,"—did not award a prize for any instrument, as, unfortunately, a limit had been set to the price of the instrument in the conditions laid down at the Hague meeting in 1907, and consequently the instruments submitted, although very good for the money, were, nevertheless, not of the precision required nowadays for earthquake investigations. The committee on "Catalogue of Earthquakes," after discussing fully the two different propositions, *viz.*—a regional and a chronological classification—satisfactorily arrived at a compromise so that investigators will have the benefits of each.

Of papers read before the Society that by Prof. Hecker on "Microseisms" was of importance. A paper by Dr. Klotz himself on the same subject contained the most positive statement on the connection between microseisms and the dynamics of the atmosphere, *viz.*: when an area of low barometer with steep gradients reaches the Gulf and Atlantic in an eastward movement we may be certain to find microseisms recorded. How the water produces them or communicates through the crust of the earth is not yet known. Here strong microseisms appear *after* the passing of the "low"; in Europe the reverse should be the case. A committee consisting of Prof. Hecker, Prince Galitzin and Dr. Klotz was appointed to further investigate the question and install a special apparatus somewhere on the sea coast for this purpose.

Dr. Klotz then gave, at considerable length, the investigation of Prof. Hecker on determining the effect of the pull of the Moon

on the solid earth. By means of a pendulum seismograph in a well about 80 feet deep, Prof. Hecker after experiments extending over seven years was able to show that, the pendulum bob described an ellipse on account of the attraction of the Moon. Comparing this result with the theory of an earth absolutely rigid, the rigidity of the earth was deduced to be somewhat greater than if made of steel.

Dr. Klotz then spoke of the glacial garden, of the platform at Strassburg for analysing seismograms and eliminating the movements of the pendulum itself; of the meteorological work being carried on there by means of balloons, automatically recording pressure, temperature and moisture; of the earthquake station near Hohenheim near Stuttgart and of the work on secular variations of terrestrial magnetism at Munich. At Heidelberg he saw the photographic plate of Prof. Wolf on which the discovery of Halley's comet on September 11 was shown.

Other magnetic and earthquake stations and observatories visited were Jugemheim, Frankfort, Leipsic, Berlin, Kiel and Hamburg.

After this Dr. King spoke for a short time on the meeting of the International Geodetic Congress in London. Referring to the work of Prof. Hecker, Dr. King pointed out that as the ellipse described by a pendulum under the Moon's attraction is flatter in a north and south direction than the theory would warrant, the conclusion would seem to be that the earth is more rigid in an east and west direction than in a north or south direction. Sir George Darwin suggests that this may be due to the rotation of the earth. The same explanation might account for the supposition of some, that earthquake tremors are transmitted faster in an east and west direction than in a north and south direction.

Referring to Prof. Hecker's determination of gravity at sea, it was pointed out that the correction required for a ship's motion destroyed to some extent the agreement of his results.

By means of a study of his deflection of the plumb line by local masses, with the torsion balance, Baron Eötvös claimed to

prove that attraction of gravity is the same for matter of different kinds within one part in ten million.

An investigation into the character of the earth's crust by Hayford led him to the conclusion that there was the same quantity of matter in a given section to a depth of 122 kilometres. Dr. Helmert and Prof. Hecker in Europe obtained results verifying this.

Six stations on the 39th parallel of N. Lat. were occupied for ascertaining the variation of latitude. There was found to be a period in the variations of 427 days, Euler had proved that with a rigid earth this period should be 306 days. The explanation is that the earth is not perfectly rigid. This hypothesis gives a co-efficient of rigidity closely agreeing with that obtained by different methods. A yearly period of variation of latitude also exists probably due to the loading of certain portions of the earth with ice. The two periods combine to give one grand period of very nearly seven years.

November 18, 7 p.m.—The lecturer for the evening was Mr. R. F. Stupart, the Director of the Meteorological Service.

Before beginning on the subject proper, "The Winds of the Globe," Mr. Stupart drew attention to the fact that of late many observers have become interested in meteorology and in the relation it bears to solar physics. Formerly the student of physics followed what he considered more alluring lines; he objected to the empirical character of weather forecasts. But though the weather forecasts may be, to some degree, empirical, yet the student of the weather must be versed in the laws of physics. In speaking of the winds of our globe Mr. Stupart gave a brief history of the growth of our knowledge of them. The first proper definition of wind was given by a Greek of Ionia, 550 B.C. The writer of Job also had a proper conception of them. But not until the invention of the barometer in 1643 did the study of meteorology receive any important impetus. The astronomer Halley in 1683 put forward a theory of the trade winds between the equator and the poles, with lateral deviations due to earth's rotation, but actual data as to the direction of the

winds have shown that Halley's theory is not correct. In the 19th century the "storm centre," an area of low pressure with winds blowing toward it, has been discovered and studied. At present the researches of Prof. Rotch, of Blue Hill Observatory, near Boston, and of Dr. Teisserenc de Bort, of Paris, France, were among the most important.

While the theorists were thus at work navigators had been collecting a vast array of data as to the winds of the sea. From these the winds of the surface of the earth were learned. The lecturer exhibited a number of slides showing the winds at different seasons.

Mr. Stupart then discussed the movements in the upper atmosphere. By means of kites and balloons it has been found that there is as a general rule a return upper current above every surface one.

The methods of forecasting the weather were then explained by means of slides. Examples of storm centres beginning in the Gulf of Mexico or along the eastern coast of North America were shown and followed in their courses. By a consideration of the usual path of storms the probable course of a storm might be forecast.

It was also shown how a storm centre, on account of the air having a slight upward tendency, might bring rain.

At the close, on motion by Dr. Bryce seconded by Dr. White, a hearty vote of thanks was tendered the lecturer.

December 16, 8 p.m.—Annual Meeting.

The following Officers were elected for 1910 :—

Chairman—Dr. Otto Klotz, LL.D., F.R.A.S.
Vice-Chairman—J. S. Plaskett, B.A.
Secretary—Carl Engler, B.A.
Treasurer—C. C. Smith, B.A.
Councillors—R. M. Stewart, M.A.
F. A. McDiarmid, B.A.
J. J. McArthur, D.L.S.

C. E.

AT PETERBOROUGH

October 26.—There was an excellent attendance, and the chair was occupied by Mr. H. B. Collier, the Vice-President for the Centre, who referred briefly to observations which he had made on the Sun, Mars and Saturn.

The chairman then called on the President for the Centre, Rev. D. B. Marsh, D.Sc., who took as his subject "A Night in the Caribbean Sea." This consisted of an illustrated travel-talk in which the speaker gave a very pleasing description of a winter trip to the Bermudas, and was illustrated by about seventy-five excellent colored views. The audience was highly delighted. The speaker drew attention to many interesting facts about this unique portion of the earth, a chief one being the great use made of the coral formation,—the work of the wonderful coral insects. The houses, churches, roads, fences, etc., are constructed of this white substance, and present a scene of spotless cleanliness and refinement. The temperature is quite uniform, ranging between 60 and 80 degrees, and the climate would be ideal were it not for the excessive moisture.

At the close of the address an interesting discussion took place, in which many questions were asked regarding the country and the climate, and were satisfactorily answered.

November 30.—Owing to circumstances for which the Local Council of the Society was not responsible, it was found necessary to postpone the regular fortnightly meeting from Tuesday evening November 16 to 30.

A feature which bespoke growing interest in the local Centre was the large attendance, composed partly of Normal School students, who had availed themselves of the opportunity of securing first hand knowledge of the subject of "Winds and Weather" as dealt with by Mr. R. F. Stupart, Director of the Meteorological Bureau of Canada. They, undoubtedly, were well repaid, as the subject was handled in such a lucid manner, and with the aid of lantern views, that no one could fail in grasping the fundamental principles.

The President was in the chair and after the reading and adoption of the minutes, he referred briefly to the profit and pleasure he had derived from his acquaintance with Mr. Stupart, and of the latter's kindness in lending to the Peterborough Centre a small but excellent telescope, which had proved of great value as well as a source of much pleasure to local astronomers.

Mr. Stupart in his address reviewed the history of meteorology, showing how little was the real knowledge of the subject until very recent years.

One slide of special interest shown on the screen was the barogram or photographic register of the barometer recorded in Toronto on August 27, 1883, this being the occasion of one of the greatest volcanic explosion that the world has ever seen, that of Krakatoa, an island in the Sunda Strait between Java and Sumatra. The great air waves started round the world and the components in opposite directions came to Toronto only a few hours apart.

Charts were shown of the actual climatic conditions in America on many specific dates, and the tracks of great storms traced day after day.

The speaker stated that in Canada there are about thirty-eight stations, one here in Peterborough, from which reports are received twice a day. These are sent on to Washington and from there sixty-five United States reports are received in return. With the aid of these and from general scientific knowledge the probabilities are forecasted.

At the close of the lecture several questions were asked the speaker, among them being a popular one, — as to whether the Moon has any influence on the weather, to which the reply was, "None whatever."

On motion of Mr. H. O. Fisk, supported by Mr. T. A. S. Hay, the speaker was tendered a vote of thanks for his very interesting and instructive lecture.

Mr. W. D. Scott was elected a member of the Society.

December 3.—A large and appreciative audience gathered this evening in the auditorium of the Collegiate Institute to hear

the distinguished arctic explorer Captain J. E. Bernier lecture on his travels.

After a few remarks from the President of the Centre, who spoke of his acquaintance with and respect for Captain Bernier, the explorer was presented with an address of welcome by Mayor Rush, on behalf of the City Council and the citizens of Peterborough.

The chairman, Hon. J. R. Stratton, M.P., then made some eulogistic remarks with reference to the lecturer for the evening, and intimated that he was present at the meeting at Captain Bernier's personal request.

Captain Bernier proved himself a very interesting speaker. He showed himself to be resourceful, with a rare fund of humor, and one who under the most trying circumstances looked on the bright side of things. His information regarding the north magnetic pole was also very interesting. When he saw the shining waters of the north-west passage he was confident that he could have claimed the "top of the world" for Canada and the British Empire, but his orders did not allow him to attempt it.

The lecturer dealt with his three trips to the North, and many remarkably fine lantern slides gave realistic views of the far north land, and exhibited the conditions of life up there in various phases.

Captain Bernier also introduced his hearer to the peculiar residents of that vast country of snow and ice, the Esquimaux, and told of their characteristics and habits of life, and of what conscientious missionaries are doing for them. He told of the seal fishing, the hunting of four-footed and winged game, and described countless other things of importance and interest.

He thought that the value of the resources of the north were not comprehended as they should be, the fisheries especially, as the rivers were alive with one of the best fish that swims, the salmon trout, and when a better means of reaching this territory is established, a highly profitable fishing ground will be found there.

At the conclusion of the lecture a very hearty vote of thanks was tendered the speaker on motion of Mr. D. Hughes-Charles supported by Dr. Marsh.

Mr. J. C. Shook was elected a member of the Society.

E. F.

At Hamilton

October 4.—The first meeting of the Fall Term of the Hamilton Centre was held in the Art Gallery of the Art School, but even this large room was not sufficient to accommodate the splendid audience which gathered to greet our ex-president, Rev. D. B. Marsh, of Springville.

Mr. Adam Brown occupied the chair, and in his usual inimitable way, added much to the success of the meeting.

In introducing the speaker, he referred to the work of Dr. Marsh in founding the Hamilton Society, and of the splendid results of this work.

Dr. Marsh spoke on the subject "Stellar Evolution and How it is Studied." He first described the Nebular theory of Laplace, as applied to the formation of the Solar System, and showed its deficiencies. Then he explained the modifications which have lately been made in it, resulting in what is known as the Spiral Nebula Theory. Each step of the lecture was illustrated with lantern slides.

In the discussion which followed, many expressions of appreciation were given, and a vote of thanks was very heartily carried.

October 22.—At this meeting, the Society was favored with a visit from the General Secretary of the R. A. S. C., Mr. J. R. Collins, of Toronto. Vice-President, Mr. William Bruce, J.P., occupied the chair.

Under the title of "The Development of Astronomical Ideas" Mr. Collins gave a very interesting talk, well illustrated with lantern slides. It was as he modestly expressed it "An attempt to outline in a popular way this interesting subject from the beginning of things to the present day." From this broad field

he selected the most important events in the history of astronomy, told their story, and showed their influence in the building up of the science to what we have it to-day.

E. H. D.

November 12.—On this evening a most instructive address was given by Mr. E. H. Darling, A.M.C.S.C.E., the indefatigable local Secretary, illustrated with numerous mechanical slides of his own construction, which were much admired. The President of the Centre occupied the chair.

The title of the lecture was "Stars in their Courses," the subject being the study of astronomy without instruments. This was further limited to the discussion of the apparent motion of the stars as seen at Hamilton.

A strong plea was made for the study of Astronomy with the naked eye. A familiar acquaintance with the stars would be a life long source of pleasure to anyone. Since the invention of the great telescopes the impression seems to be that only those equipped with such can study astronomy. But astronomy was a science before the telescope was invented. There is evidence that the ancients were careful observers of the heavens 4700 years ago, and it is really wonderful what they knew about the subject.

One of the mechanical slides used by the lecturer illustrated the daily rotation of the star sphere, and this motion was explained by means of several diagrams.

Many different phenomena may be explained by this motion, such as the seasons, solar and sideral time, the varying altitudes of the Sun, Moon and planets during the year, the harvest moon, the culmination of stars, etc. In this connection, slides were shown taken from photographs of star trails.

The slower motions of the earth affecting the position of the stars were touched on—the motion of the axis of the earth due to the precession of the equinox which has a period of 26,000 years, and the variation of the position of the north and

south poles of the earth, which amounts to a maximum of about thirty feet.

The apparent motion of the planets was discussed with maps showing the loop of Mars in 1900, and of both Mars and Jupiter for this present year. One photograph of the Pleiades had the trail of a meteor right across it.

The motions of binary stars, star drift and runaway stars, were touched on. Another slide made from a photograph, showed the alterations in the light of a variable star.

Sun flames, as seen by means of the spectroscope were spoken of as the most spectacular example of motion to be found in the heavens.

On the motion of Mr. T. H. Wingham, B.A.Sc., seconded by Rev. J. J. Morton, a hearty vote of thanks was tendered to Mr. Darling.

Mr. G. Parry Jenkins, F.R.A.S., exhibited some beautiful lantern slides of Jupiter, Saturn and the Moon, made from drawing by Mr. Scriven Bolton, F.R.A.S., the one of Saturn having been awarded a gold medal at the recent Franco-British Exhibition in London, England.

G.P.J.

November 26.—The Society this night had a meeting even more successful than usual. It was held in the Board of Trade Room, but the seating capacity of this large room was not sufficient to accommodate the large audience.

Mr. W. A. Robinson occupied the chair.

The speaker of the evening was the popular local president, Mr. G. Parry Jenkins, F. R. A. S., and the subject, which excited so much interest, was "Halley's Comet."

The ground covered by Mr. Jenkins included the history of periodic comets, an explanation of cometary orbits, and the latest theories regarding the composition and behaviour of these strange bodies. Referring more particularly to Halley's Comet, he told of its many historical returns to the Sun, and how again it has been discovered on its way towards us. He also outlined what

we may expect to see of this comet during the coming spring and summer. The lecture was illustrated by many fine slides.

In the discussion which followed, one of our members, Mr. D. Kneeshaw, gave a description of the comet of 1843, which he well remembered seeing. Many others took part in the discussion which incidently demonstrated that our members are thinking of and studying astronomical subjects.

December 10.—One of the most practical and instructive lectures this Centre has ever had, was given on this date by Professor Louis B. Stewart, D.L.S., second Vice-President of the R. A. S. C., Toronto. Its title was "The Determination of Positions in High Latitudes." By means of the Sextant, Transit, Artificial Horizon, and black board diagrams, Professor Stewart demonstrated the actual process of finding the latitude and longitude of any station on the earth's surface. In connection with the question of longitude, he explained the method of finding the local time by means of the transit, and the sextant, and the use of the Nautical Almanac and chronometer.

In the course of his lecture he showed the great difficulties in the way of applying the usual methods to determine the latitude and longitude of a station near the earth's pole. As the Arctic explorer must make his dash to the pole in the summer season, he is deprived of the use of the stars and must depend on the Sun for his observations, and even this body is always unfavorably situated for anything like exact measurements.

In answer to a question, he stated that fictitious observations for a point near or at the North Pole could be easily made. He also stated that he knew of no observation which could be made at the pole which would absolutely prove that the observer had actually been at that point.

On motion of Mr. W. A. Robinson, seconded by Mr. W. Bruce a hearty vote of thanks was tendered Professor Stewart.

The following papers have been arranged for:

December 22, "Looking Up and Looking Down" (Illustrated)
Julius M. Williams, Consulting Chemist, Hamilton.

January 14, 1910, "Star Geography" (Illustrated) Miss Elsie A. Dent, Recording Secretary R. A. S. C., Toronto.

January 28, "The Artistic Side of Astronomy" —Second Part (Illustrated) William Bruce, J.P.

February 11, "Comets" (Illustrated) Alfred T. DeLury, M.A. Professor of Mathematics University of Toronto

February 25, E. Walter Maunder, F.R.A.S., Superintendent of Solar Department, Greenwich Observatory, has promised to contribute a paper on some Solar Phenomena, which will be read at this meeting. Full title will be announced later.

E.H.D.

NOTES FROM THE DOMINION OBSERVATORY

Astrophysics

Spectroscopic Binaries under Observation at the Dominion Observatory.

A list of the spectroscopic binaries under investigation at the various observatories engaged in this line of work was published by Prof. Frost in the *Astrophysical Journal* for March, 1908. Since that date, however, several on the Ottawa list have been completed, one or two have been abandoned on account of poor quality of spectra combined with small range of velocity, and some new ones have been added. It has seemed desirable, therefore, to publish now a list of the binaries on which we are at present engaged.

The orbits of the five following stars are well under way, three of them being nearly completed.

φ Persei
τ Tauri
ν Orionis
93 Leonis
η Boötis

Work on the orbits of the twelve following stars is in progress and is fairly well advanced in some of them.

θ^2 Tauri
7 Camelopardalis
θ^2 Orionis
γ Geminorum

α' Ursæ Majoris
γ Corvi
ε Ursæ Minoris
δ Herculis
B.A.C. 5890
α Ophinchi
ε Cygni
γ Aquarii

Although orbits have been completed and published for the following five stars, radial velocity observations are being continued. In the case of η Virginis and α Draconis, in order to obtain more accurate values of the elements, velocities in different parts of the curves are being obtained and least squares corrections will be applied. In the remaining three, however, it is practically certain that the elements are changing and this with the presence of secondary and other unexplained effects renders further observation and discussion advisable.

β Orionis
η Virginis
α Draconis
ε Herculis
θ Aquilæ

In addition to the above a few early type stars suspected of having variable velocity are being observed occasionally.

It may be of interest to mention that it has been found desirable, in most of the binary stars under investigation here which have early type spectra with diffuse lines and in which consequently the errors of measurement are high, to obtain considerably more plates than are usually considered necessary. The number of plates used for the 9 orbits determined here averages 98 and by the time the two mentioned above are completed will be well over 100. Even if the orbit of β Orionis, for which the abnormally large number of 273 was used, be deducted the average number will still be nearly 80.

J.S.P.

THE SEISMOGRAPH—BOSCH PHOTOGRAPHIC, 200 GRAMMES—

The following earthquakes have been recorded since the last notes were sent.

1909		N–S Component	E–W Component
June 22		h m s	h m s
	1st P. T.	13 15 42 G.M.T.	13 15 44 G.M.T.
	2nd P. T.	13 25 00	13 25 00
	P. P.	13 38·5	13 38
	Maximum	13 49	. . .
	End	14 10	14 25
	Epicentre 8,000 km.		
June 28			
	1st P. T.	. . .	(?) 7 33 36
	2nd P. T.	. . .	7 45 26
	P. P.	8 15 30	8 14 36
	Maximum	. . .	8 20
	End	8 55	9 15
	Epicentre 11,100 km.		
July 7			
	1st P. T.	21 50 42	21 50 43
	2nd P. T.	22 00 54	22 00 55
	P. P.	22 20	22 19 30
	Maximum	22 22	22 22
	End	23 15	23 50
	Epicentre over 9,000 km.		
July 13			
	1st P. T.	(?) 13 25	13 24 47
	2nd P. T.	13 34	13 34 00
	P. P.	. . .	. . .
	End	13 45	14 10
July 17			
	Sharp inset	10 55	10 55 21
	End	. . .	11 10
July 20			
	Inset	18 41 56	18 41 23
	End	18 46	18 46

		N-S Component	E-W Component
		h m s	h m s
July 21	1st P. T.	4 07 27	4 07 17 G.M.T.
	Maximum	4 20	4 20
	End	4 37	4 50
	Wave	1 55 40	1 55 30
	End	3 02	3 02
July 25			
	Wave	. . .	7 56 20
	Sharp inset	8 02 46	8 02 30
	Maximum	. . .	8 17
	End	8 30	8 57
July 30			
	1st P. T.	10 58 44	10 58 44
	2nd P. T.	11 04 16	11 04 16
	P. P.	11 07 40	. . .
	Maximum	. . .	11 15
	End	12 30	13

Epicentre 3,750 km. Earthquake in Mexico.

		h m s	h m s
July 31			
	Waves	. . .	10 00
	End	. . .	10 25
	1st P. T.	19 25 48	19 25 48
	2nd P. T.	19 31 20	19 31 20
	P. P.	19 38	. . .
	Maximum	. . .	19 42
	End	20 10	21 25

Epicentre 3,750 km. Mexico.

August 1			
	Waves	. . .	21 48
	End	. . .	22 22
August 5			
	Waves	12 16 42	12 07 30
	End	15	15
August 7			
	Wave	. . .	17 07 22
	2nd P. T. (?)	. . .	17 17 40
	Maximum	. . .	17 48
	End	. . .	18 45

August 14	N–S Component	E–W Component
	h m s	h m s
1st P. T.	6 54 46	6 54 47 G.M.T.
2nd P. T.	. . .	. . .
P. P.	7 16	7 16
Long Waves	7 22 20	7 21 40
Maximum	7 31	7 31
End	8 02	8 13

Epicentre 10,600 km.

August 17		
1st P. T.	7 06 13	7 06 14
2nd P. T.	7 12 11	7 12 12
P. P.	7 18 12	7 18 12
Maximum	7 20 30	7 18 30
End	8 15	8 32

Epicentre 4,700 km.

August 18		
1st P. T.	. . .	1 00 09
2nd P. T.	. . .	1 10 14
P. P.	1 33 30	1 36
Maximum	. . .	1 42
End	. . .	2 27

August 31		
1st P. T.	12 04 43	12 04 29
2nd P. T.	12 10 24	12 10 24
Maximum	12 11 08	12 11 20
P. P.	12 14	. . .
End	12 47	13 00

Epicentre 3,900 km.

September 8		
1st P. T.	16 59 25	16 59 25
2nd P. T.	17 07 19	17 07 19
P. P.	17 14	17 14
Maximum	17 18	17 22
End	19	20

Epicentre 6,400 km.

September 16		
Wave	20 01 50	20 01 50
P. P.	20 25	20 25
End	20 40	20 45

September 19		N–S Component	E–W Component
		h m s	h m s
	Waves	20 28	20 28 G.M.T.
	Maximum	20 45	20 45
	End	21 00	21 20
October 2			
	Waves	8 11	8 11 17
	End	8 18	8 22
October 3			
	Waves	15 08	15 08
	Maximum	. . .	15 11
	End	15 15	15 20
	Waves	17 06 22	17 06 23
	Maximum	17 10	17 13 40
	End	17 17	17 23
	Waves	21 03 21	21 03 21 (?)
	Maximum	21 04	21 07 30
	End	21 21	21 35
October 18			
	Waves	. . .	8 36
	Maximum	8 47 40	8 49
	End	9 00	9 25
October 21			
	Waves	0 06	0 06
	P. P.	. . .	0 27
	Maximum	0 33	0 33
	End	1 25	1 30
October 29			
	Waves	. . .	7 00
	Maximum	7 06 52	7 06 52
	End	7 15	7 30

Earthquake at Eureka (?) California

October 31. For this earthquake unfortunately the relay to cut off light for the time-scale failed. Hence the time for 1st P. T. is assumed although approximate. The other phases are based thereon.

	h m s	h m s
1st P. T.	10 30 00 $\pm x$	10 30 04 $\pm x$
2nd P. T.	10 35 40	10 35 46
P. P.	10 39 20	. . .
Maximum	10 45 04	10 46
End	11 30	12 00

Epicentre 4,000 km.

		N–S Component	E–W Component
		h m s	h m s
November 10			
	1st P. T. (emergence)	6 41	6 41 G.M.T.
	Inset	6 47 13	6 47 15
	P. P.	. . .	6 47 26
	Long waves	6 49	6 49
	End	7 50	8 25
November 14			
	1st P. T.	11 58 48	
	End	12 15	12 20
November 21			
	Long waves	8 37	8 33
	End	. . .	9 06
November 22			
	2nd P. T. (?)	19 52 22	19 52 22
	P. P.	. . .	20 02
	End	. . .	21

Terrestrial Magnetism

During the past season observations were made for declination, inclination and horizontal intensity at 31 stations along the north shore of the St. Lawrence from Quebec to the Straits of Belle Isle, a distance of 750 miles and covering 14° of longitude. The instrument used was the Tesdorpf Magnetometer outfit. Observations were also taken for diurnal variation. The territory covered is considerably of a terra incognita as far as the magnetic elements are concerned, and hence the data obtained the more valuable.

For the next issue of The Journal we will probably have the data ready for publication.

O.K.

Dominion Observatory,
Ottawa, Canada,
Dec. 2, 1909.

NOTES FROM THE METEOROLOGICAL SERVICE

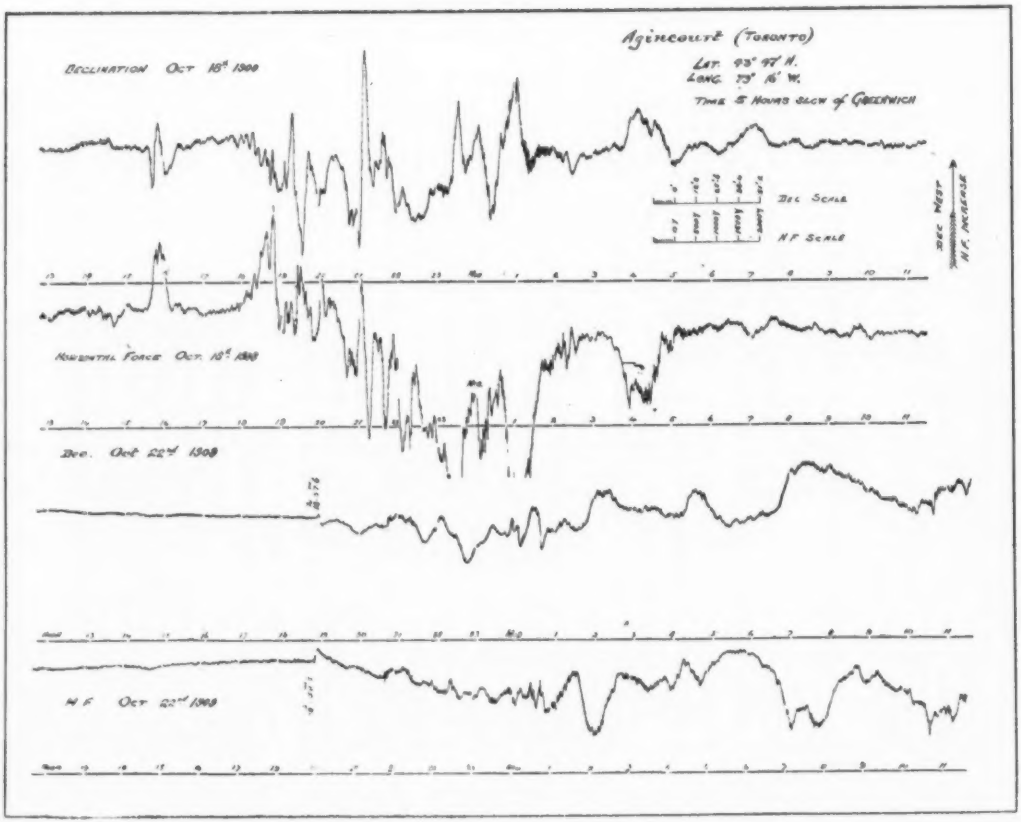
MAGNETIC OBSERVATIONS

During the months of October and November the records from magnetic instruments at Agincourt (Toronto) show three disturbances which occurred on the 18th of October, 22nd of October and the 30th of November.

Inspection of the traces for the disturbance of the 18th of October shows the beginning marked by a long wave in both declination and bifilar instruments of about two hours and a half duration and then a return to almost normal conditions. The amplitude in this wave was about 31 minutes in declination and 115γ in horizontal force. At $15^h\ 36^m$, shorter waves in larger amplitude began in declination lasting until about $5^h\ 00^m$ of October 19th when the magnet gradually quieted down. The range in amplitude during this period of disturbance was 2° 4′ in declination and generally the declination was below normal. In the bifilar trace the changes were more intense and the beginning occurred at $15^h\ 32^m$ with a sudden increase in force of about 140γ. With progression of the storm the force decreased until the light disappeared between 23 hours and midnight for about 16 minutes, and again for about the same period between 1 and 2 hours of October 19th. As in the declinations the magnet quieted down after 5 hours of October 19th.

The disturbance of the 22nd October began at $18^h\ 58{\cdot}5^m$ in the bifilar with a very sudden increase in force. In the declination it began at $18^h\ 57{\cdot}6^m$ with a sudden decrease of westerly declination. The progression of the storm was marked by moderately long waves on both instruments. The amplitude in declination was 57·6 and that in horizontal force 210γ.

On the 30th of November another small disturbance occurred showing an amplitude of 59′ in declination and 225γ in horizontal force.


Agincourt (Toronto)
Lat. 93° 97' N.
Long. 79° 16' W.
Time 5 Hours slow of Greenwich
Declination Oct 18th 1909
Dec Scale
H.F. Scale
Dec West
H.F. Increase
Horizontal Force Oct 18th 1909
Dec. Oct 22nd 1909
H.F. Oct 22nd 1909

The two first disturbances are of peculiar interest, having occurred approximately at an interval of one Solar rotation after the great disturbance of September 25th.

The mean monthly declination for October was 6° 1'·9 W. and for November 6° 1'·6 W. R.F.S.

Summary Report of the Weather in Canada

October, 1909

Temperature—Along the British Columbian Coast and in the Cariboo District, and from Western Quebec to the Maritime Provinces, the mean temperature of October was above the normal, whilst elsewhere in Canada it was below.

In the Western Provinces the normal value was very closely approached, but in a few localities the negative departures amounted to 3°. In Ontario, a negative departure of 2° was pretty general, and in parts of the peninsula it was as much as 3° and 5°, while in the extreme east it diminished to just normal. From Montreal eastward positive departures increased, and in Prince Edward Island and Cape Breton were as much as 5° and 8°.

Precipitation—In British Columbia the precipitation recorded during October was generally in excess of the average. This was also the case in Eastern Quebec and the Maritime Provinces, exclusive of South-western Nova Scotia, where the normal value was not reached. Throughout the remaining districts of Canada, the fall, with local exceptions, was less than average, the deficiency being particulary marked in the Western Provinces where the amount was about half the average.

November, 1909

Temperature—The mean temperature for November exceeded the average from Eastern Saskatchewan to the Maritime Provinces, while in other parts of Canada the values were subnormal.

Negative departures from average were pronounced in Alberta and Northern British Columbia, amounting to from 3 to 10 degrees.

In Northern and Central Ontario and in the Eastern portion of the Maritime Provinces the positive departures were generally from 3 to 6 degrees, while in other districts, where the normal was exceeded, the difference was only from 1 to 2 degrees.

Temperatures for October and November

Station	October		November	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	54	−1	28	−45
British Columbia				
Atlin	46	13	36	−28
Agassiz	68	29	61	25
Barkerville	54	19	39	12
Kamloops	66	27	55	10
New Westminster	71	34	54	21
Port Simpson	55	32	50	18
Vancouver	65	35	56	23
Victoria	69	37	55	25
Western Provinces				
Battleford	79	8	54	−26
Broadview	79	7	—	—
Calgary	72	19	56	−12
Carman	86	5	—	—
Edmonton	76	3	56	−27
Medicine Hat	80	17	63	−15
Minnedosa	83	4	55	−15
Moosejaw	77	8	59	−11
Oak Bank	80	12	59	−12
Portage la Prairie	87	12	57	−11
Prince Albert	75	6	55	−28
Qu'Appelle	78	4	57	−18
Regina	78	2	59	−15
Swift Current	74	6	58	−8
Winnipeg	82	11	59	−6
Ontario				
Agincourt	77	21	67	12
Aurora	76	17	63	3
Bancroft	80	14	68	−2
Barrie	70	21		
Beatrice	75	17	65	8
Birnam	77	27	67	11
Bloomfield	77	20	70	13
Brantford	77	21	68	14
Bruce Mines	68	18	57	3
Chatham	82	25	70	20
Clinton	73	27	65	10
Cottam	77	19	66	20
Cockburn Island	74	19	60	8
East Toronto	74	20	60	12
Gravenhurst	75	16	66	1
Haliburton	75	11	65	4
Hamilton	72	25	68	18
Huntsville	74	10	74	4
Kenora	78	14	52	−2
Kinmount	74	13	61	8
Kingston	76	20	64	14
Lakefield	74	23	66	7
London	81	24	69	15
Lucknow	78	24	67	5
Madoc	77	20	67	9
Meaford	73	25	67	10
Midland	78	25	70	7
North Gower	80	20	74	8
Otonabee	76	25	62	10
Ottawa	74	22	63	7
Owen Sound	76	23	67	4
Paris	72	24	63	15
Parry Sound	74	14	69	5
Peterboro'	80	18	68	6
Point Clark				
Port Arthur	65	12	57	2
Port Burwell	75	25	62	14
Port Dover	75	24	62	15
Port Hope	78	21	60	10
Port Stanley	69	25	60	14
Ronville	73	18	65	6
Sarnia	74	23	66	12
Southampton	77	24	68	5
Stonecliffe	79	15	61	−11
Stony Creek	79	22	68	21
Stratford	75	23	65	13
Toronto	77	21	64	14
Uxbridge	73	18	64	6
Wallaceburg	82	25	69	27
Welland	75	23	65	21
White River	78	6	56	−10
Quebec				
Brome	79	14	63	4
Father Point	67	26	50	12
Montreal	73	24	60	11
Quebec	72	23	55	12
Sherbrooke	75	21	61	12
Maritime Provinces				
Charlottetown	71	32	59	21
Chatham	75	28	62	14
Dalhousie	74	30	50	13
Fredericton	78	25	60	18
Halifax	74	30	63	20
Moncton	73	23	67	14
St. John	73	29	58	21
St. Stephen	80	22	59	15
Summerside				
Sussex	75	24	60	16
Sydney	69	29	68	25
Yarmouth	73	29	63	24

Precipitation—During November an exceptionally heavy rainfall occurred over the Southern Coast districts of British Columbia, the total amount averaging nearly twice the normal quantity. From Ontario to the Maritime Provinces, with few exceptions the fall exceeded the average, whereas it was almost generally deficient over the Prairie Provinces.

Snow fell occasionally in all the Provinces, and on the last day of the month from 1 to 8 inches were reported to be on the ground in the West and from 1 to 4 inches in Quebec.

Earthquake Records by Milne's Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 H = midnight.

No.	Date 1909	P.T Comm h	P.T Comm m	L.W. Comm.	Max. h	Max. m	End. h	End. m	Max. Amp. mm.	Durat. h	Durat. m	Remarks
872	Oct. 3	21	2·0				21	6·5	0·10	0	4·5	
873	" 17	1?		Doubtful								
874	" 18	8	40·4				8	55·4	0·40	0	15·0	
875	" 21	0	26·4		0	50·4	1	32·0	0·70	1	5·6	
876	" 25	7	6·4				7	11·0	0·15	0	4·6	Eureka, California
877	" 31	10	5·2				10	10·4	0·10	0	5·2	Very small and decided
878	" 31	10	35.1	10 40·7	10	43·0	11	56·0	1·6	1	20·9	Moderate
879	Nov. 10	6	37·6				8	16·5	0·4	1	38·9	Japan
880	" 12	4	33·2				4	48·0	0·1	0	14·8	Max. at beginning
881	" 21	8	39·5				8	57·0	0·07	0	17·5	
882	" 22	20	9·2				20	38·2	0·10	0	29·0	

Toronto boom. Vibration 14·8 seconds. Angular value 0″·64

VICTORIA, B. C.

E. B. Reed, Superintendent.

No.	Date 1909	P.T. Comm. h	P.T. Comm. m	L.W. Comm.	Max. h	Max. m	End h	End m	Max. Amp. mm.	Durat. h	Durat. m	Remarks
899	Oct. 2	7	54·8				7	59·8	0·10	0	5·0	
900	" 3	20	57·8				21	2·3	0·06	0	4·5	
901	" 15	9	54·0				10	2·0	0·08	0	8·0	
902	" 17	1	43·0				1	50·0	0·05	0	7·0	
903	" 18	8	40·0				8	55·0	0·5	0	15·0	Gradually tailed off
904	" 21	0	29·0		0	52·0	1	30·0	0·9	1	1·0	Well defined
905	" 29	6	51·1				7	5·0	0·9	0	13·9	Eureka, California
906	" 31	10	29·5	10 43·5	10	46·5	11	48·5	3·1	1	19·0	
907	Nov. 10	6	25·2		10	34·6	8	13·4	1·0	1	48·2	Small and extended. Japan
908	" 21	8	27·4				8	39·4	0·05	0	12·0	
909	" 22	19	48·5				20	37·5	0·05	0	49·0	

Vibration of boom 15 seconds. Angular value 0″ 76.

J. Y.

ASTRONOMICAL NOTES

THE SYSTEMATIC MOTIONS OF THE STARS. F. W. Dyson, F.R.S.—A systematic character in the proper motions of the stars was discovered by Herschel, and attributed to the motion of the solar system. Different methods gave very different results for the direction of this motion. Thus Airy and Argelander placed the apex in declination + 35°, Bessel in − 5°. In 1895 Dr. Kobold called attention to these discrepancies, which seemed to point to an error in the fundamental hypothesis that the peculiar motions of the stars have no preference for any particular directions. In 1905 Kapteyn, from the proper motions of 2,400 stars given in Auwers-Bradley, showed that the proper motions relative to the Sun exhibited preference for two special directions, and that when the solar motion was subtracted the stars were moving in two streams in opposite directions relative to their centre of gravity. These relative motions were directed towards, and away from, the star ξ Orionis (R.A. 91°, declination + 13°). Eddington, discussing the proper motions of 4,500 stars in the Groombridge Catalogue determined by Dyson and Thackeray, also found that the stars formed two drifts in good agreement with Kapteyn's results. Confirmation was obtained from 1,200 stars within 10° of the North Pole, and from 2,000 zodiacal stars. Schwarzschild showed that the Greenwich-Groombridge proper motions might be satisfactorily explained by supposing that the peculiar motions of the stars did not obey Maxwell's law for haphazard distribution, but that the resolved parts in one direction were all increased in a definite ratio. Beljawski applied this to the stars of large proper motion in Porter's catalogues. Prof. Dyson determined the favoured directions from all proper motions greater than 20″ a century. Of 1,800 stars examined it was possible to assign 1,100 to one drift and 600 to the other, 100 showing no systematic motion. All these results are in close accord, since all agree in showing an increase of the peculiar

velocities in one direction and the opposite, this direction being nearly the same in all cases. This direction is in the plane of the Milky Way, but it is too early to offer any explanation of the motions. (*Nature*, November 4).

WITH the range between freezing point and boiling point less than half as great as on the Earth, the range of temperature within which water will remain in the liquid state is much reduced, whilst with the atmospheric pressure so slight at the surface of the planet, the diurnal range of temperature will be much increased. The form of water that we on the Earth regard as normal is the liquid state. But that cannot be the normal form for Mars. For that planet, water must most frequently show itself as ice or the related forms of snow or hoar frost, and when either of these forms under the influence of the Sun's heat is melted, the intermediate state, that of the liquid, will be easily and quickly passed through—much more quickly than on the Earth. On the Earth aqueous circulation is carried on both by ocean currents and by the transportation of water vapour in the atmosphere. There is nothing on Mars to correspond to the vast ocean surfaces of the Earth, and from the ease with which water will pass into vapour it is clear that we must look to the atmospheric circulation as the chief means for the transference of moisture from one region to another.

And, indeed, this is readily enough admitted by all writers on Martian meteorology, so far as it relates to the transfer of moisture towards the pole; it is only when the question of the movement in the opposite direction arises that it is assumed to be impossible that the moisture should travel in the form of vapour, and it is found imperative to cover Mars with a Titanic system of irrigation works fitted with mammoth pumping stations at short intervals. Yet the atmospheric circulation of Mars cannot be always in one and the same direction. If anything, one would suppose that the winds blowing in summer time from the melting pole cap would be more heavily laden with vapour than those blowing in winter towards the freezing cap.

Yet a further point. If we have water currents conducted

aiong carefully constructed canals in order to convey water from the melting pole cap towards the equator, their flow cannot be uninterrupted. The polar regions are, indeed, enjoying perpetual sunlight, and melting and evaporation will go on fast and furiously; but as the water approaches the tropics, it will be exposed through ever-lengthening nights to rapid radiation, and soon a point will be reached whereat night after night the canals would be frozen solid.

It will be remembered that even for the equator of Mars we found a climate resembling that suggested by places on the Earth like Archangel. In other words, that the mean temperature was definitely below freezing point. This would mean that even great expanses of water were frozen to the bottom at night, and that the daily melting could be only superficial. It would be only shallow masses of water that could be completely thawed in the course of a 12-hour day. There would be every degree of melting from the equator to the poles, but it would be near the poles alone that a complete liquefaction could take place.—E. W. Maunder, *Journal British Astronomical Association*, November, 1909.

Generalising from a representative example, we might consider all parts of the Martian surface which show evidence of change to be covered by vegetation, and all those which remain fairly constant during the course of ages to represent either large sheets of water, or even desolate plains, like those of our satellite.

No one ever saw a single artificial canal on Mars, and it is the opinion of Mr. A. Stanley Williams that the Meudon observations have disproved "for ever the existence of the systems of hard, geometrically patterned lines with which some observers have so elaborately endowed the planet." And the minor details or "canals" in perfect harmony with Mr. Maunder's theory, have assumed a more irregular, knotted, disconnected, and, to put it plainly, a more *natural-looking* appearance. We thus see in the so-called "canals" a work of Nature, not of Intellect; the spots relieving the gloom of a wilderness, and not the Titanic

productions of supernatural beings. To account for their various phenomena, we need only invoke the natural agencies of vegatation, water, cloud, and inevitable differences of colour in a desert region. Some of them are mere isolated dusky features; the majority are knotted bands; others look like rivers with their tributaries; while a few would seem to lie in pairs, like the irregular streaks radiating out of the more important walled plains of the Moon.

Such was the doom of that geometrical network, and such our gropings as to the physical condition of Mars. There is hardly any more fascinating sight in the universe than this little planet—the only living and probably still inhabited world showing us the intricate details of its very surface. And should it be objected that the views here chosen have assumed too geomorphic, or even too selenomorphic a character, the excuse would be that, in framing physical theories, the scientific imagination cannot transcend the world of fact and experience.—E. M. ANTONIADI, *Journal British Astronomical Association*, November, 1909.

THE plane of the comet's orbit makes an angle of 18° with the Earth's orbit plane. The comet's orbit therefore passes "through" the planetary orbits like the two adjacent links of a chain. The comet will approach within fifty-six million miles of the Sun, and then recede during thirty-eight years until it is far beyond *Neptune's* path. In perihelion it must travel thirty-four miles per second, but at the outer turning its speed will be less than one mile a second.

Since the coming of photography and the accurate recording of details of comet structure utterly invisible to the eye, it has been possible to measure these motions. Comparisons of photographs of the same comet made two or three hours apart have shown that condensations and other structural forms have moved rapidly outward during the interval; only a few miles per second at first, but faster and faster as the distance out in the tail increased. Some observed speeds have been nearly fifty miles per second. Fifty miles per second is more than four million miles per day. If such motions exist, the constituents of the tail on

one night are not the constituents of the tail of the following nights. Half a century ago the great physicist, Clerk-Maxwell, in developing the electro-magnetic theory of light, deduced mathematically that the so-called light and heat-waves, in striking upon any object, exert a pressure upon that object, very much as ocean waves falling upon the cliffs press against the obstructing rocks. The pressure due to light and heat-waves, called radiation pressure, is extremely slight ; so slight, in fact, that skilled experimenters were unable to detect its existence for many years. At last, about the year 1900, a Russian physicist, Lebedew, was able to observe this effect ; and a few months later two American physicists, Nichols and Hull, were even more successful, for their accurate observations showed a satisfactory agreement with the demands of Maxwell's theory.

All the materials of a comet are necessarily attracted by the Sun, according to the law of gravitation. There can be no doubt that they are also acted upon by radiation pressure. The former seeks to draw all into the Sun, the latter to drive them into outer space. These are opposing forces. On the more massive parts of a comet, comprising the nucleus, radiation pressure is ineffective ; and the nucleus moves along in its prescribed curve with remarkable precision. Not so with the finely divided materials of the coma and tail. Gravity acts as a function of a particle's mass, whereas radiation pressure's action is dependent upon the surface-area of a particle in relation to its mass. As particles become smaller and smaller a size will be reached such that these opposing forces will be precisely balanced. Particles larger than these will be drawn nearer to the Sun. Particles smaller will recede from the Sun.

Astronomers will welcome the coming of Halley's Comet, full of hope that the photo-dry-plate, the spectroscope, and other ways and means of attack invented since its last visit in 1835 will enable them to remove something of the mystery of comets, the most mysterious of all celestial bodies.—PROF. W. W. CAMPBELL, *Publications Astronomical Society of the Pacific*, No. 128.

J.R.C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

Query

How soon can Halley's Comet be detected, before it reaches the Sun, with a 12-power binocular glass; and near what star will it be.—G. J. B.

Answer

It is not possible to state definitely when the comet will be visible in 12-power binoculars; likely, however, before the end of February. For the location, consult the map appearing in this issue under "Predictions."

It may be interesting to consider this question of brightness somewhat further.

The variation in the brightness of a comet is somewhat capricious. It depends, of course, on the distance of the comet from the Sun and from us, and also whether it is seen only by reflected sun-light or in part by its own light. These questions are not entirely settled yet, and it is hoped that progress will be made in their solution by observations of Halley's comet on its present apparition.

In the ephemeris computed by Father Searle (Harvard *Bulletin*, No. 372) the brightness on March 1 is given as 30, that on September 11 being assumed as 1. Now on September 16 the magnitude was 16 (See this JOURNAL, last issue, p. 343) A thirty-fold increase in brightness would make the magnitude 12·3 on March 1, to see which would require about a 5-inch telescope.

Again Cowell and Crommelin in their Search Ephemeris (*M.N.*, LXVIII., p. 394, March 1908), assuming the brightness

on January 2 to be 1, compute the following values for the brightness:

February 3,	1·13	May 10,	1112·0
March 13,	2·05	May 14,	660·7
March 23,	4·83	May 18,	94·18
April 4,	8·95	May 22,	33·27
April 12,	13·06	May 26,	15·49
April 20,	19·30	May 30,	8·59
April 28,	28·31	June 7,	3·51
May 2,	58·34	June 23,	1·00
May 6,	126·5	July 13,	·35

From the above computations one would hardly expect the comet to be visible to the naked eye before May, but I believe it is quite generally expected that it will be considerably before that time.

The circumstances of the last two apparitions are as follows:

1759—Perihelion passage, March 12.

December 25, 1758—First seen by Palitzch, an amateur astronomer, near Dresden, with a telescope of 8-feet focus.

December 28, seen by Dr. Hoffmann.

January 21, 1759, seen by Messier at Paris. Then lost in the Sun's rays. Inferior conjunction, end of February; not seen again until March 26. Towards end of April became invisible in Europe, but seen in southern hemisphere.

April 28, seen at Lisbon again, and continued to be seen until June 3.

May 5. In southern hemisphere tail was seen 47° long and comet was a conspicuous object.

1835—Perihelion passage, November 16.

August 5, seen at Rome, a very faint telescopic nebula.

August 20, generally visible (in telescopes), small round or slightly oval nebula, no tail.

September 23, first seen with the naked eye.

October 2, tail began to form and increased rapidly.

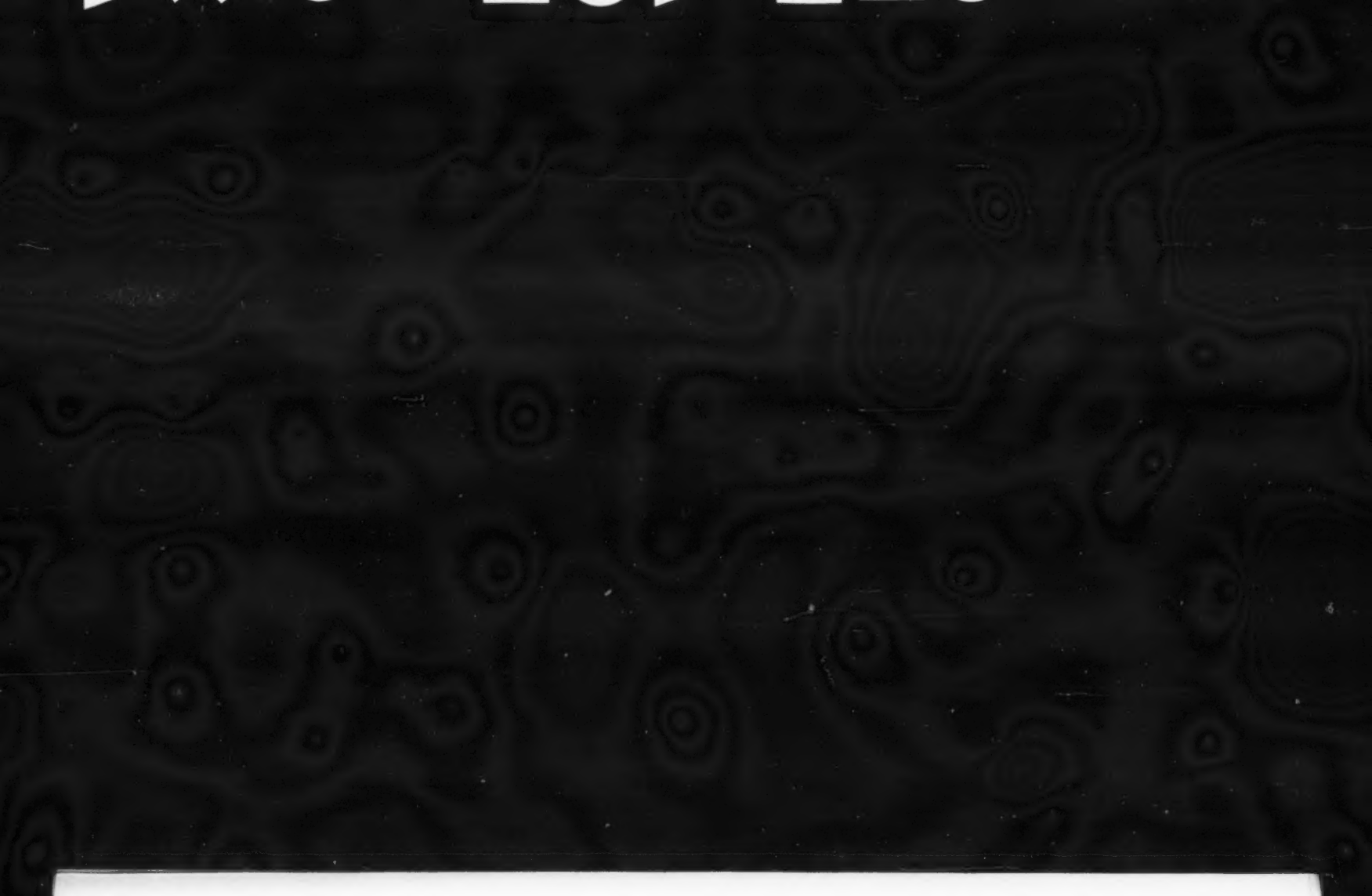
October 5, tail 5° long.

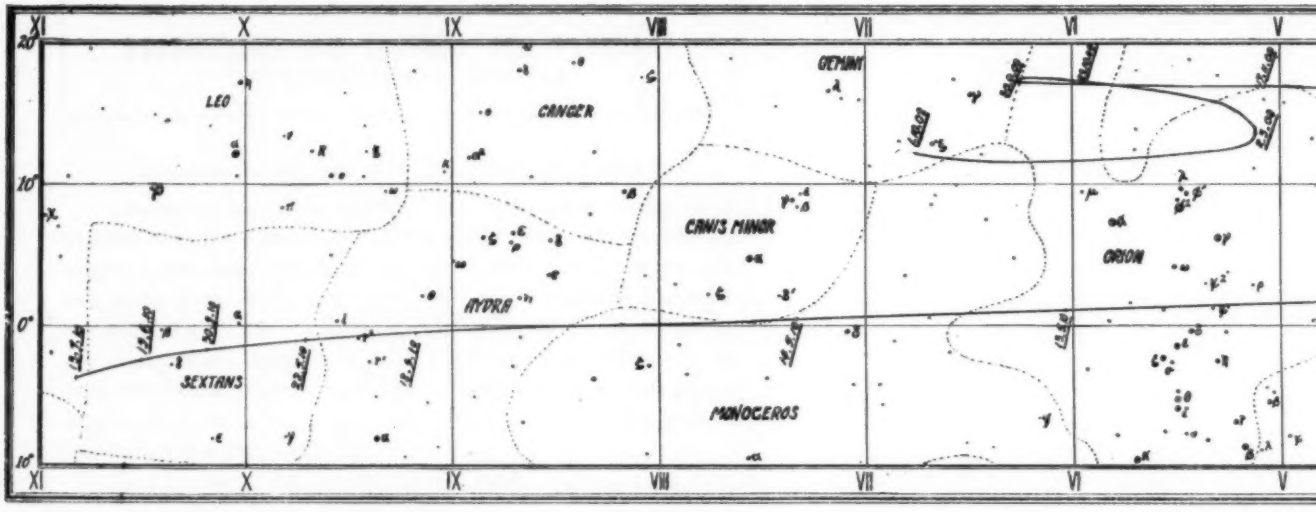
October 15, tail about 20° long, its greatest apparent length. From this time it decreased.

October 20, tail 3° long.

November 5, tail 2½° long: entirely disappeared before perihelion. After this it disappeared for two months and at its re-appearance (January 24, 1836) it was quite different in appearance, having no tail and appearing to the eye like a hazy star of 4th or 5th magnitude (See Herschel's "*Outlines of Astronomy.*")

C.A.C.



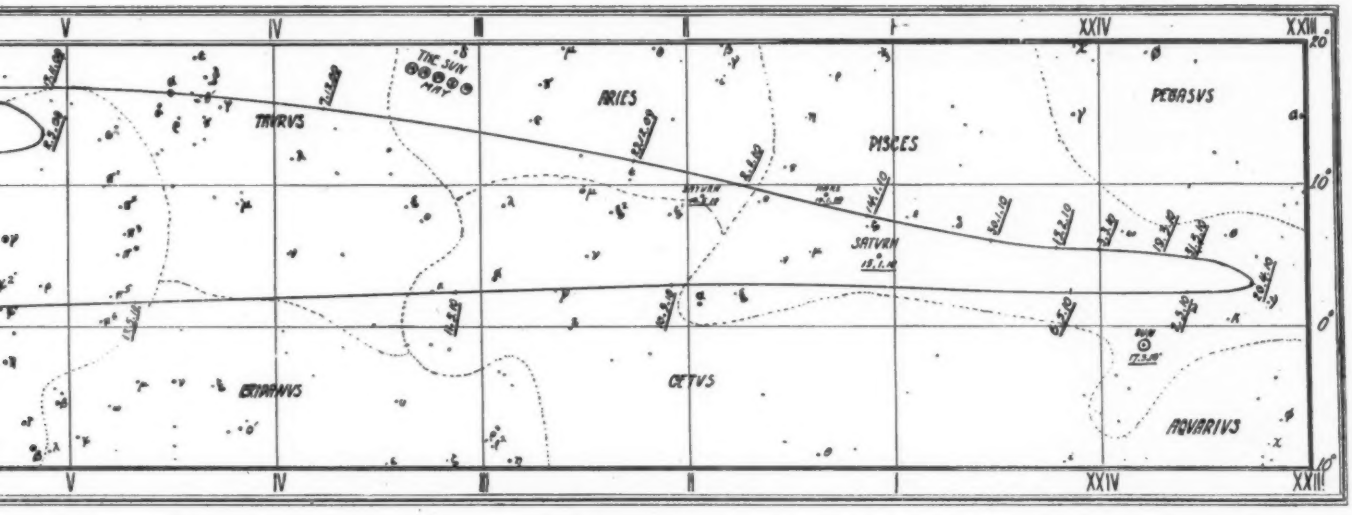


PATH OF HALLEY'S COMET AMONG THE STARS FROM OCTOBER

THE above map is drawn from the ephemeris prepared by Cowell and Crommelin (*Monthly Notices*, Vol. LXVIII., p. 394-5, March 1908). According to the elements deduced by these astronomers the perihelion passage should be April 8, 1910, at a distance 0·5869 or 54·6 millions of miles. On the map is shown the position of the Sun on March 17 and on May 10, 11, 12, 13, 14; of Saturn on January 15, and May 15; and of Mars on January 10, 1910. The position of the comet on the dates given (for example 11.5.10 = May 11, 1910) is indicated by a little mark across the curve showing the path.

The comet was re-discovered by
berg, by photography. He first de
taken August 28, but did not a
September 11. The ephemeris of C
time of the re-discovery required a
right ascension and 4 minutes in dec
satisfactory when we remember tha
made nearly 74 years ago.

A re-calculation since the re-di
the perihelion passage about 10 d
nearest approach to the earth will b



OCTOBER 1, 1908 TO JULY 13, 1910. (DRAWN BY A. B. FENNELL).

covered by Dr. Max Wolf, of Heidel-
He first detected the image on a plate
did not announce his discovery until
meris of Cowell and Crommelin at the
equired a correction of 25 seconds in
utes in declination, which is extremely
ember that the last observations were

the re-discovery of the comet makes
bout 10 days later, or April 19. The
rth will be on May 19, distance about 14,000,000 miles, but the comet will be so near the Sun that it will probably not be visible. On May 18 the earth will likely pass through the comet's tail.

The date at which it will be visible to the naked eye is uncertain, but probably it will be bright enough some time during February. At that time it will be seen in the western sky after sunset. Towards the end of March after passing the Sun it will appear in the morning before sunrise, and it will reach its greatest apparent distance from the Sun in May. Towards the middle of May it will again pass the Sun and reappear in the evening sky.

C. A. C.

PREDICTIONS FOR JANUARY AND FEBRUARY

PREPARED BY R. M. STEWART

Constellations on the Meridian in January

Camelopardalis (The Giraffe) is a large polar constellation situated between Cassiopeia and the Great Bear. Whatever the origin of the name, the constellation includes a long narrow lane extending down to the east of Polaris, which might be likened to the neck of a giraffe. The outlines of many of the constellations are so extremely irregular and arbitrary that it is difficult to see how they could have originated. Camelopardalis contains no bright stars, there being only one of the fourth magnitude and a number of the fifth and sixth.

Auriga (The Charioteer) may readily be recognized by Capella, its brightest star, which crosses the meridian very slightly north of the zenith at 9 p.m. on January 24th. It is the most northerly of the first magnitude stars, and is surpassed by only a few in brilliance. It is followed 43 minutes later by β, of the second magnitude ; the specific name of this star is Menkalinan, but is now practically never used. The south-western half of the constellation, which is traversed by the milky way, contains many fine star-clusters.

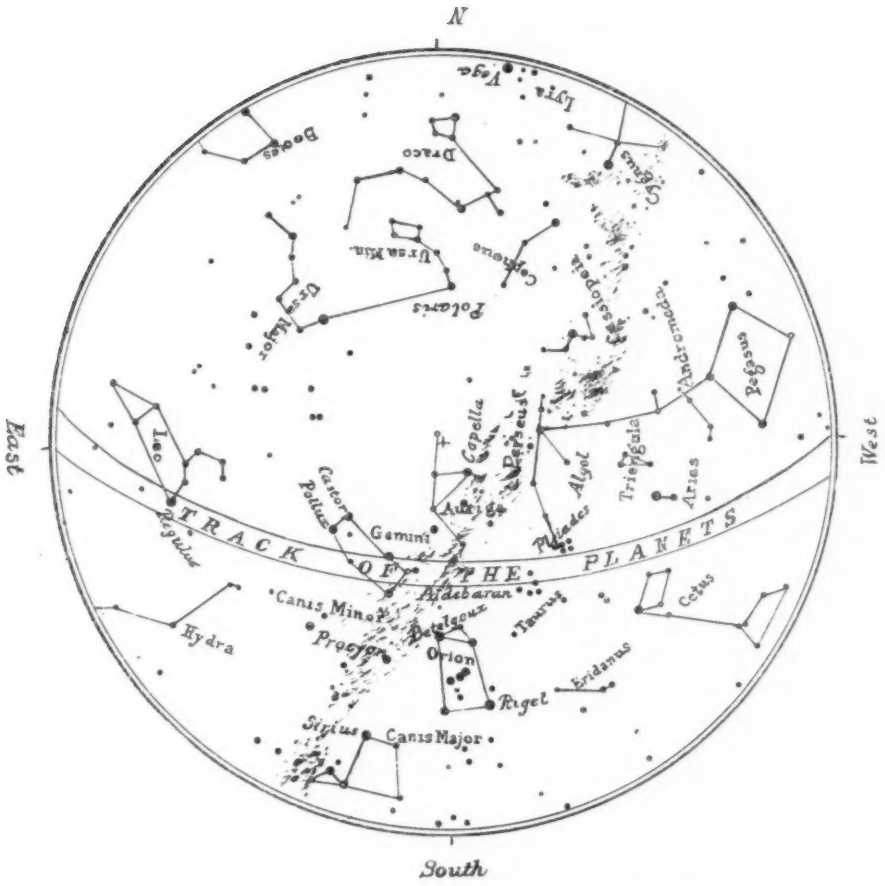
Taurus (The Bull) is situated directly south-west of Auriga; it is the second sign and the third constellation of the zodiac, and is occupied by the Sun from May 13 till June 18. It is most easily recognized by the Pleiades, or Seven Stars, which cross the meridian about nine o'clock on January 1 ; this group is well worth examination with an opera glass or *small* telescope. About 15° to the south-east is the red first magnitude star Aldebaran, the brightest in the constellation ; it is at one end of a group of

five stars forming the shape of a V, well known as the Hyades; this is another small group which will well repay examination with an opera glass. The only other conspicuous star is β, or Nath, to the north-east of Aldebaran and almost south of Capella; it is of the second magnitude.

Orion, which is named from a giant of mythological history, is the only constellation which really suggests the figure of the object it is supposed to represent. It is also the most beautiful and brilliant constellation of all, being studded with stars of the first, second and third magnitudes. The three stars of second magnitude in a close row form the belt; the upper one of these is on the equator. From these depend three others, known as the Sword of Orion; the centre one, θ, appears slightly hazy to a good eye; when examined with a telescope it is seen to be quadruple, and to be surrounded by a nebula, the Great Nebula of Orion. The left knee of the giant is marked by Rigel, of the first magnitude, the right knee by κ, of the second; the two shoulders by Betelgeuse and Bellatrix, of the first and second magnitudes respectively; the head is a small triangle formed by one star of the fourth and two of the fifth magnitude.

Constellations on the Meridian in February

Canis Major (The Great Dog), lies to the south-east of Orion. It is marked by Sirius, The Dog Star, which is by far the brightest of the fixed stars, forming a magnitude by itself. It is at a distance of about seventeen light-years; hence it must be of stupendous magnitude and brilliancy. From irregularities in its proper motion it was shown that it must have a dark companion revolving about it. This was confirmed by Alvan Clark's discovery in 1862 of a companion of the tenth magnitude. The period of revolution is about fifty years, the companion having about one-half the mass of Sirius. About five or six degrees west of Sirius is β, of the second magnitude; further to the south are δ and ϵ, of the second magnitude, and two other stars of the third, all in the same constellation.



CONSTELLATIONS AT 9 P.M. ON FEBRUARY 1.

Canis Minor (The Lesser Dog) is to the east of Orion and slightly higher. The name of its brightest star, Procyon, signifies "Before the Dog," being given to it because it rises shortly before Sirius; it forms an equilateral triangle with Sirius and Betelgeuse. From the proper motion of Procyon it was shown theoretically by Bessel that it must, like Sirius, have a companion revolving around it. This companion was discovered at the Lick Observatory by Prof. Schaeberle in 1896, very nearly in the predicted position.

Gemini (The Twins) is the third sign and the fourth constellation of the zodiac. It derives its name from the Twin Stars, Castor and Pollux, of the first magnitude; they are separated by about four and a half degrees, and lie to the south-east of Capella, and some distance directly to the north of Procyon. Castor is a double star, the components revolving about one another in about 1000 years. Some distance to the south-west is γ, of the second magnitude; the constellation also includes several third and fourth magnitude stars. It is occupied by the Sun from June 18 to July 18.

Mercury

Mercury is an evening star until January 25, at which time it is in conjunction with the Sun; afterward a morning star. On January 10 it is at its greatest elongation east, when it sets about an hour and a half after the Sun; at the greatest elongation west on February 19 it is less favorably situated for observation, being farther south of the Sun and consequently not rising so long before him. It is in conjunction with the Moon on January 12 and February 8, and with Venus on February 27.

Venus

Venus, which reached its greatest apparent distance from the Sun on December 2, does not attain its greatest brilliance until January 7. It remains above the horizon for over three hours after sunset, and will be the most conspicuous object in the heavens. It is in conjunction with the Sun on February 12,

after which it becomes a morning star. It will be noticed from the Table of Planetary Phenomena given elsewhere in these Predictions, that on February 9, while it is still east of the Sun, it is in conjunction with the Moon, whereas the latter, which is moving towards the east, does not reach conjunction with the Sun (that is, New Moon does not occur) till nearly forty minutes later. Thus we have apparently the anomalous condition that

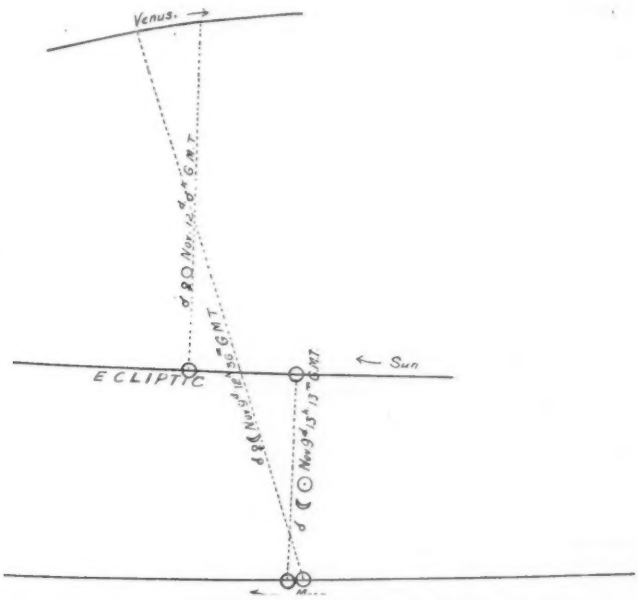


FIGURE TO ILLUSTRATE CONJUNCTION IN RIGHT ASCENSION AND IN LONGITUDE

the Moon is at the same instant both east and west of the Sun. The explanation lies in the fact that a planet is considered to be in conjunction with the Moon when the two bodies have the same *right ascension*, while conjunctions of other bodies with the Sun are reckoned by equality of *longitude*, which is measured along the ecliptic. The accompanying figure, which gives the paths

of the three bodies and their positions at the times of the different conjunctions, will explain how the phenomenon is possible.

Mars and Saturn

These two planets, which at the beginning of the year pass the meridian together at about half past six in the evening, separate continually during January and February, Saturn sinking to the west much more rapidly than Mars. By the end of February the former sets a few minutes after nine, while Mars remains above the horizon till after midnight.

Jupiter

Jupiter begins to retrograde on January 30; its whole motion among the stars during January and February is so small that it would be enclosed in a circle of double the diameter of the Moon. It is in quadrature with the Sun on January 4, and rises shortly after midnight; by the end of February, however, it appears above the horizon shortly before nine in the evening.

Meridian Passage of the Principal Planets in January and February

LOCAL MEAN TIME

	For January 15		For February 15
Mercury	1.20 P.M.	Sagittarius, Capricornus	10.29 A.M.
Venus	2.27 P.M.	Capricornus, Aquarius	11.43 A.M.
Mars	5.57 P.M.	Pisces, Aries	5.05 P.M.
Jupiter	5.19 A.M.	Virgo	3.16 A.M.
Saturn	5.29 P.M.	Pisces	3.35 P.M.
Uranus	11.56 A.M.	Sagittarius	10.01 A.M.
Neptune	11.38 P.M.	Gemini	9.32 P.M.

Some Interesting Doubles Visible in Small Telescopes

7 *Camelopardalis*. R. A. $4^h\ 50{\cdot}1^m$; Dec. 53° 37′; magnitudes 4·2, 11·3; distance 25″·6; white and orange; the brighter star has another close olive-colored companion of the eighth magnitude at a distance of 1·2; the latter is a somewhat difficult object.

β Orionis. R. A. $5^h\ 10{\cdot}2^m$; Dec. $-8°\ 18'$; magnitudes 1, 8; distance $9''{\cdot}1$; position angle 200°; a very difficult object in any but the best telescopes, on account of the brilliance of the primary.

δ Orionis. R. A. $5^h\ 27{\cdot}4^m$; Dec. $-0°\ 22'$; magnitudes 2, 6·8; distance $52''{\cdot}7$; colors white and pale violet. This is the preceding of the three stars in the belt of Orion.

λ Orionis. R. A. $5^h\ 30{\cdot}2^m$; Dec. 9° 52′; magnitudes 4, 6; distance $4''{\cdot}2$; colors pale yellow and purplish. This star, with φ_1 and φ_2, forms a triangle to the naked eye, which constitutes the head of Orion.

θ Orionis. R. A. $5^h\ 30{\cdot}9^m$; Dec. $-5°\ 28'$; the trapezium in Orion, situated in the densest part of the Great Nebula; four stars A, B, C, D; magnitudes 6, 7, 7·5, 8; position angles and distances, A B 32°; $8''{\cdot}7$: A C 131°; $12''{\cdot}9$: C D 60°; $13''$: there are a number of other smaller stars in the neighborhood, several of which are supposed to be variable.

σ Orionis. R. A. $5^h\ 34{\cdot}2^m$; Dec. $-2°\ 39'$; a beautiful multiple star of about the fourth magnitude. In most ordinary telescopes it presents the appearance described by Sir Wm. Herschel as "a double-treble star, or two sets of treble stars almost similarly situated." In larger instruments both sets are seen to be quadruple.

ζ Orionis. The following of the three stars in the belt of Orion. R. A. $5^h\ 36{\cdot}2^m$; Dec. $-1°\ 59'$; magnitudes 2, 5·7, 9; distances $2''{\cdot}2$, $57''$; colors yellow, purplish, grey.

11 *Monocerotis.* R. A. $6^h\ 24{\cdot}5^m$; Dec. $-6°\ 58'$; three components A, B, C; magnitudes, A 5; B 5·5; C 6; distances, A B $7''{\cdot}2$; B C $2''{\cdot}5$; A C $9''{\cdot}5$; a striking object.

δ Geminorum. R. A. $7^h\ 14{\cdot}7^m$; Dec. 22° 9′; magnitudes 3·2, 8·2; distance $7''{\cdot}1$; colors white and purple; a rather difficult double.

α Geminorum. (Castor). R. A. $7^h\ 28{\cdot}9^m$; Dec. 32° 5′; magnitudes 2·7, 3·7; distance $5''{\cdot}8$. This is the largest and

finest double star in our hemisphere, and was the first shown to be certainly of a binary character ; the period is 1000 years.

κ Geminorum. R. A. $7^h\ 39{\cdot}0^m$; Dec. 24° 37′ ; magnitudes 4, 9 ; distance 6″·3 ; very delicate and beautiful.

Clusters and Nebulæ

H.VII.,33 Cluster. R. A. $5^h\ 13{\cdot}9^m$; Dec. 39° 15′. Sir Wm. Herschel describes this as "a pretty compressed cluster, with one large star, the rest nearly of a size." The principal star is of the eighth magnitude, and of a bright orange color.

M.38. R. A. $5^h\ 22{\cdot}7^m$; Dec. 35° 45′. A fine cluster, described by Admiral Smyth as "an oblique cross, with a pair of large stars in each arm, and a conspicuous one in the centre, the whole followed by a bright individual of the seventh magnitude." There are several wide doubles scattered through it, and the whole region is very beautiful.

M.1. R. A. $5^h\ 29{\cdot}1^m$; Dec. 21° 57′. The Crab Nebula ; resolved by the 6 ft. reflector of the Earl of Rosse into a star-cluster. Its accidental discovery by Messier when following a comet in 1758 led to the formation of the earliest catalogue of nebulæ.

M.42. The Great Nebula of Orion. R. A. $5^h\ 30{\cdot}9^m$; Dec. – 5° 27′. The fainter portions of this nebula extend over an immense space ; it has been shown by photography to cover a large part of the constellation. The telescope shows an irregular branching mass of greenish haze, in some directions moderately well defined where the dark sky penetrates it in deep openings, in others melting imperceptibly away over a large extent of space. It has been shown by the spectroscope to be gaseous, and has been thought to be variable.

M.37. R. A. $5^h\ 46{\cdot}3^m$; Dec. 32° 31′ ; a fine cluster, resolvable into about 500 stars from the tenth to the fourteenth magnitudes. "Even in smaller instruments extremely beautiful, one of the finest of its class. Gaze at it well and long."—*Webb*.

M.35. R. A. $4^h\ 3{\cdot}3^m$; Dec. 24° 21′. A beautiful and extensive region of small stars.

H.IV.45. R. A. $7^h\ 23{\cdot}9^m$; Dec. 21° 16′. A star of the eighth or ninth magnitude, surrounded by a bright nebulous atmosphere of about 25″ diameter; a very remarkable object.

ECLIPSES AND TRANSITS OF THE SATELLITES OF JUPITER

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, e = egress.

Eastern Standard Time; hours numbering from midnight.

JANUARY

d	h	m			d	h	m			d	h	m		
3	5	54	II.	ED	**12**	6	11	II.	Se	**22**	5	38	I.	Te
5	0	53	II.	SI	**13**	5	51	I.	SI	**23**	0	16	II.	Te
	3	21	II.	TI	**14**	2	55	II.	OR		2	55	I.	OR
	3	38	II.	Se		3	12	I.	ED	**24**	0	05	I.	Te
	5	02	II.	Te		6	37	I.	OR	**26**	0	56	III.	ED
	6	50	I.	ED	**15**	0	19	I.	SI		3	28	III.	ER
6	3	57	I.	SI		1	32	I.	TI		5	44	III.	OD
	5	11	I.	TI		2	35	I.	Se	**28**	2	57	II.	ED
	6	13	I.	Se		3	46	I.	Te	**29**	4	06	I.	SI
7	1	19	I.	ED		6	50	III.	SI		5	14	I.	TI
	4	45	I.	OR	**16**	1	04	I.	OR		6	21	I.	Se
8	0	41	I.	Se	**19**	1	57	III.	OD	**30**	0	03	II.	TI
	1	54	I.	Te		4	12	III.	OR		0	33	II.	Se
	2	52	III.	SI		5	59	II.	SI		1	26	I.	ED
	5	39	III.	Se	**21**	0	22	II.	ED		2	42	II.	Te
9	3	13	IV.	SI		5	04	I.	ED		4	44	I.	OR
	4	31	IV.	Se		5	26	II.	OR		23	41	I.	TI
12	0	23	III.	OR	**22**	2	12	I.	SI	**31**	0	50	I.	Se
	3	26	II.	SI		3	24	I.	TI		1	55	I.	Te
	5	53	II.	TI		4	28	I.	Se		23	12	I.	OR

FEBRUARY

d	h	m			d	h	m			d	h	m		
2	4	53	III.	ED	**13**	1	23	III.	Se	**20**	5	20	III.	Se
4	5	33	II.	ED		2	50	III.	TI		5	28	II.	SI
5	5	59	I.	SI		2	55	II.	SI		6	20	III.	TI
	23	14	III.	TI		4	50	II.	TI	**21**	4	15	I.	SI
6	0	22	II.	SI		4	56	III.	Te		5	05	I.	TI
	1	22	III.	Te		5	12	I.	ED	**22**	0	03	II.	ED
	2	27	II.	TI		5	38	II	Se		1	33	I.	ED
	3	06	II.	Se	**14**	2	21	I.	SI		4	21	II.	OR
	3	19	I.	ED		3	18	I.	TI		4	33	I.	OR
	5	06	II.	Te		4	37	I.	Se		22	43	I.	SI
	6	33	I.	OR		5	32	I.	Te		23	32	I.	TI
7	0	28	I.	SI		23	40	I.	ED	**23**	0	59	I.	Se
	1	30	I.	TI	**15**	1	59	II.	OR		1	45	I.	Te
	2	43	I.	Se		2	47	I.	OR		22	10	III.	OR
	3	44	I.	Te		23	05	I.	Se		22	56	II.	Te
	23	35	II.	OR		23	58	I.	Te		22	59	I.	OR
8	1	00	I.	OR	**20**	2	40	III.	SI	**28**	6	09	I.	SI
12	23	43	III.	SI										

AT GREENWICH MEAN NOON

Date 1909	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Sub't from Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Sat. 1	1	18 44 27·37	S. 23 3 30·2	3 25·73	18 41 1·64
Tues. 4	4	18 57 41·12	22 47 22·3	4 49·80	18 52 51·32
Fri. 7	7	19 10 51·46	22 27 9·9	6 10·46	19 4 41·00
Mon. 10	10	19 23 57·62	22 2 58·5	7 26·95	19 16 30·67
Thur. 13	13	19 36 58·79	21 34 54·0	8 38·44	19 28 20·35
Sun. 16	16	19 49 54·25	21 3 4·1	9 44 23	19 40 10·02
Wed. 19	19	20 2 43·38	20 27 37·3	10 43·69	19 51 59·69
Sat. 22	22	20 15 25·76	19 48 42·6	11 36 41	20 3 49·36
Tues. 25	25	20 28 1·11	19 6 29·4	12 22 07	20 15 39·04
Fri. 28	28	20 40 29 31	18 21 7·6	13 0·60	20 27 28·70
Mon. 31	31	20 52 50·29	S. 17 32 47·2	13 31·92	20 39 18·37

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

			Minima of Algol	Configuration of Jupiter's Satellites at 3h.
			h m	
Sat.	1	6h ♁ in Perihelion; 22h ♀ in ☊.		♃14○2
Sun.	2		18 10	32○14
☾ Mon.	3	8h 19m ☌ ♃ ☾, ♃ 3° 11′ S.; 8h 26 8m Last Quarter.		312○4
Tues.	4	1·4h ☾ Apogee; 14h □ ☉.		3○124
Wed.	5		14 58	1○234
Thur.	6			2○134
Fri.	7	11h ♀ Greatest brilliancy; 15h □ ♄ ☉.		○234●
Sat.	8	21h ☍ ♆ ☉.	11 47	1○324
Sun.	9			32○14
Mon.	10	7h ☿ Greatest elongation E. 19° 3′. [♁ ☾, ♁ 3° 9′ N.		3214○
♉ Tues.	11	♄ Greatest Hel. Lat. S.; 6h 51·2m New Moon; 7h 14m ☌	8 36	43○12
Wed.	12	0h ☌ ♁ ☉; 16h 14m ☌ ☿ ☾, ☿ 4° 33′ N.		41○23
Thur.	13	10h ♀ in ☊; 22h 22m ☌ ♀ ☾, ♀ 7° 43′ N.		42○13
Fri.	14		5 25	41○23
Sat.	15			♃4○32
Sun.	16	18h ☿ Stationary. [23h □ ☍ ☉.		432○1
Mon.	17	8·5h ☾ in Perigee; 10h 45m ♑ ♄ ☾ ♄ 1° 34′ N.;	2 14	3421○
☽ Tues.	18	0h ☿ in Perihelion; 2h 19m ☌ ☍ ☾, ☍ 4° 25′ N.;		3○412
Wed.	19	[5h 20·6m First Quarter.	23 03	1○24●
Thur.	20	8h ♀ Stationary.		2○143
Fri.	21			1○34●
Sat.	22		19 52	○1324
Sun.	23	23h 4m ☌ ♆ ☾, ♆ 4° 5′ S.		32○14
Mon.	24			321○4
♈ Tues.	25	6h 50·6m Full Moon.	16 41	3○124
Wed.	26	4h ☌ ☿ ☉ Inferior.		1○42●
Thur.	27			24○13
Fri.	28	7h ☿ Greatest Hel. Lat. N.	13 30	41○3●
Sat.	29			4○132
Sun.	30	4h ♃ Stationary; 19h 5m ☌ ♃ ☾. ♃ 2° 45′ S.		423○●
Mon.	31	22·7h ☾ in Apogee.	10 19	4321○

Key to Symbols.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ♁ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

AT GREENWICH MEAN NOON

Date 1909	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Sub't from Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Tues. 1	32	20 56 55·68	S. 17 16 2·5	13 40·75	20 43 14·93
Fri. 4	35	21 9 7·02	16 24 0·0	14 2·43	20 55 4·60
Mon. 7	38	21 21 11·18	15 29 23·5	14 16·92	21 6 54·26
Thur. 10	41	21 33 8·19	14 32 24·1	14 24·26	21 18 43·93
Sun. 13	44	21 44 58·13	13 33 13·5	14 24·53	21 30 33·60
Wed. 16	47	21 56 41·13	12 32 3·7	14 17·88	21 42 23·26
Sat. 19	50	22 8 17·47	11 29 6·0	14 4·55	21 54 12·93
Tues. 22	53	22 19 47·55	10 24 32·1	13 44·96	22 6 2·59
Fri. 25	56	22 31 11·84	9 18 32·7	13 19·59	22 17 52·25
Mon. 28	59	22 42 30·89	S. 8 11 17·8	12 48·98	22 29 41·91

75th Meridian Time, Hours numbering from Midnight

		Planetary Phenomena	Minima of Algol	Configuration of Jupiter's Satellites at 2h.
			h m	
Tues.	1			43○12
☾ Wed.	2	6h 27·1m Last Quarter.		413○2
Thur.	3		7 08	24○13
Fri.	4	12h ☿ in Perihelion.		12○43
Sat.	5			○1234
Sun.	6	19h ♆ Stationary.	3 57	13○24
Mon.	7	19h 25m ♂ ♌ ☾, ♌ 3° 19′ N.		2413○2○4
Tues.	8	1h 7m ♂ ☿ ☾, ☿ 6° 25′ N.		3○124
● Wed.	9	19h 36m ♂ ♀ ☾, ♀ 13° 34′ N.; 20h 13.0m New Moon.	0 46	31○24
Thur.	10			2○134
Fri.	11		21 35	12○43
Sat.	12	7h ♂ ♀ ☉ Inferior; 17·0h ☾ in Perigee.		○4123
Sun.	13	20h 21m ♂ ♄ ☾, ♄ 1° 18′ N.		41○32
Mon.	14		18 24	432○1
Tues.	15	13h 11m ♂ ♂ ☾, ♂ 3° 1′ N.		43○2●
☽ Wed.	16	13h 32·5m First Quarter.		431○2
Thur.	17		15 13	42○13
Fri.	18			421○3
Sat.	19	23h ♆ Greatest elongation W. 26° 33′.		4○123
Sun.	20	4h 33m ♂ ♆ ☾, ♆ 4° 10′ S.; 18h ☿ in ☌.	12 02	14○32
Mon.	21			32○14
Tues.	22			3○4●●
○ Wed.	23	22h 35·8m Full Moon.	8 51	31○24
Thur.	24			2○314
Fri.	25			21○34
Sat.	26	10h ♀ Greatest Hel. Lat. N.	5 40	○1234
Sun.	27	0h 34m ♂ ♃ ☾, ♃ 2° 29′ S.; 16h ♂ ♆ ♀, ♆ 9° 18′ S.		1○324
Mon.	28	17·6h ☾ in Apogee.		23○14

For Jupiter's Satellites, the circle ○ represents the disc of the planet; ♃ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc or in the shadow. Configurations are for an inverting telescope.

Variable Stars

Name	R. A.		Dec.		Mag.	Period
	h	m	°	′		
α Cassiopeiæ	0	35·4	56	03	2·2 to 2·8	
R Trianguli	2	31 6	33	53	5·6 to 12	262 days
δ Persei	2	59·4	38	30	3·3 to 4·2	Irregular
λ Tauri	3	55·7	12	14	3·4 to 4·2	3d 22h 52m 12s
ε Aurigæ	4	55·5	43	41	3·0 to 4·5	Irregular
R Leporis	4	55·5	−14	56	5·8 to 8·5	435 days
δ Orionis	5	27·4	− 0	22	2·2 to 2·7	
α Orionis	5	50·3	7	23	1 to 1·4	200 days
η Geminorum	6	09·4	22	32	3·2 to 4	229·1 days
T Monocerotis	6	20·4	7	08	5·7 to 8	27·0037 days
S Monocerotis	6	36·0	9	59	5·0 to 5·5	
ζ Geminorum	6	58·8	20	42	3·7 to 4·5	10d 3h 41·5m
R Canis Maj.	7	15·4	−16	13	5 7 to 6·5	1d3h 15m46s
U Monocerotis	7	26·5	9	35	5·7 to 8	45·20 days

Radiant Points of Meteor Showers

Date	R. A.		Dec.	
	h	m	°	
January 1-3	15	28	49	The Quadrantids; near φ Herculis
January 2	15	20	53	Near ι Draconis; a rich shower
January 5	9	20	57	Near θ Ursæ Majoris
January 5-11	9	40	5	Near 4 Sextantis
January 17	19	40	53	Near ε Cygni
January 28	15	44	25	
February 5-10	4	56	43	
February 15	15	44	11	Near α Serpentis
February 16	11	08	5	
February 20	12	04	34	
February 20	17	32	36	Near δ Herculis

Occultations of Stars by the Moon*

Date	Star	Mag.	Time				Position Angle	
			Immersion		Emersion		Immersion	Emersion
			h	m	h	m	°	°
Jan.	3 *l Virginis*	4·8	14	52·1	15	56·1	151	277
"	5 *v Libræ*	5·3	18	4·2	19	12·2	90	335
"	5 22 *Libræ*	6·5	18	24·3	19	44·8	130	294
"	14 *τ Aquarii*	4·4	4	55·7	6	1·7	41	254
"	20 53 *Tauri*	5·3	10	41·4	11	46·4	51	280
"	23 *A Geminorum*	5·1	11	48·2	13	5·2	112	266
"	26 *η Leonis*	3·6	9	52·9	10	45·4	66	332
"	28 *v Virginis*	4·2	12	23·4	13	26·9	87	338
Feb.	19 37 *Geminorum*	5·7	5	53·4	6	48 9	127	222
"	26 46 *Virginis*	6·1	15	21·6	16	19·1	171	261
"	26 48 *Virginis*	6·5	17	27·1	18	39·1	112	310

*Prepared by R. M. Motherwell for use at the Dominion Observatory.

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EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

W. F. KING
Chief Astronomer
Ottawa

R. F. STUPART
Director of the Meteorological Service of Canada, Toronto

J. S. PLASKETT
Dominion Observatory
Ottawa

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